Provo Canyon
Traffic Analysis

Utah and Wasatch Counties

Submitted to:
Utah Department of Transportation

August 2000
1004-310

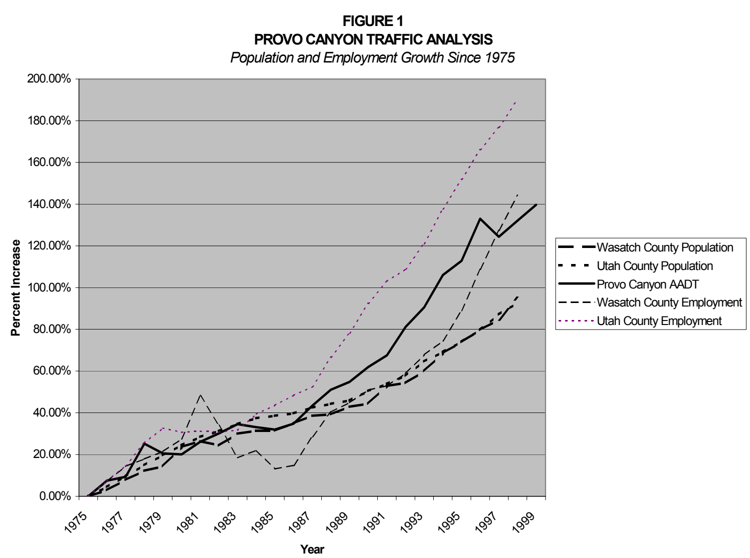
Summary of Findings

Planning efforts to improve US-189, Provo Canyon, have been in progress for almost 25 years. An Environmental Impact Statement (EIS) was first prepared in 1978, which resulted in the recommendation to widen and improve the canyon road to two lanes with continuous passing lanes in each direction from US-89 in Orem to US-40 in Heber. A civil action was filed in 1986 resulting in the preparation of a Supplemental EIS in 1989. Various improvements to the canyon road, which are consistent with the 1989 SEIS, began in 1991, and progressed from the lower section of the project (near US-89 in Orem) in a northeast direction. At present, the project has been completed from the Murdock Junction to Vivian Park, improvements from Vivian Park to Wildwood are underway, and design (and an environmental re-evaluation) has been completed from Wildwood to Deer Creek State Park. The final section from Deer Creek State Park to Heber is identified at a conceptual level in the 1989 SEIS. The purpose of this report is to:

- Document traffic use patterns in the canyon
- Identify the overall demand for roadway improvements
- Identify traffic issues that may have changed since earlier analyses.

<u>Traffic Growth Trends</u>

UDOT counts of average daily traffic in the canyon between 1975 to1999 were compared against both population and employment growth in Utah and Wasatch Counties. Figure 1 displays the normalized growth in traffic against the growth in population and employment. Growth in traffic strongly mirrors the socio-economic (population and employment) trends of adjacent Utah and Wasatch Counties. Growth in these areas was characterized by moderate growth throughout the late 1970s and early 1980s, flat growth in the mid-1980s, and strong growth from the late 1980s throughout the 1990s. A decrease in the AADT in 1997, was likely due to construction impacts and short duration road closures in the canyon.



1: Traffic and Socio-Economic Growth

The traffic growth taking place in the canyon today is relatively unaffected by short-term impacts on parallel routes (such as the recent and on-going re-construction of I-15 in Salt Lake County or the prior upgrade of US-40). The relationship between socio-economic variables and daily traffic indicates an extremely strong relationship between traffic growth and population trends.

Traffic projections prepared in the 1978 EIS and 1989 SEIS were based on a trend analysis of past traffic growth, which resulted a projected growth rate of traffic volume between 3.2 percent and 3.7 percent to the year 2010. The 1995 environmental re-evaluation based traffic growth on both a trend analysis and a linear regression of regional (five county) population figures. The low end traffic forecast of 10,863 AADT projected for the year 2010 (using 1.3 percent annual growth) was almost passed by year 2000 traffic counts (10,285 AADT). The present analysis based traffic on population and employment forecasts in Utah and Wasatch Counties and resulted in a forecast growth rate of between 2.2 percent and 3.4 percent to the year 2020. It can be concluded that average daily traffic will continue to grow similarly to the growth of population and employment of the adjacent counties. According to forecasts published by the Utah Governor's Office of Planning and Budget, both counties are projected to experience strong growth patterns for the foreseeable future.

Weekday and monthly variations of traffic volumes were also reviewed. The canyon continues to display recreational traffic patterns characterized by highest daily volumes on Saturdays and highest monthly volumes in July and August. Other than continued increases in traffic since the 1978 EIS, the 1989 SEIS, and the 1995 environmental re-evaluation, weekday and seasonal traffic patterns have not changed. The use of the 50th highest hour for design purposes continues to be appropriate. However, since the 50th highest hour appears to be declining as a percentage of daily traffic (although increasing as a value), the canyon is less subject to large traffic variations due to recreational uses as opposed to more day to day use.

Diverted Truck Traffic

One concern of recommended improvements in Provo Canyon was that long distance (interstate) trips could be diverted from Parley's Canyon to Provo Canyon if Provo Canyon were improved. This issue was raised in earlier environmental documents. Although all traffic may possibly be diverted from I-80 Parley's Canyon to Provo Canyon, the greatest concern of diverted traffic is related to trucks. The Fehr & Peers work reviewed this issue from two vantage points. First, a truck survey and truck counts were performed to identify changes in use of Provo Canyon with the construction impacts of I-15. Second, attitudes of truck drivers were also surveyed to gain an understanding of the types of transportation improvements that would cause truck drivers and interstate travelers to alter routing. The results of the Fehr & Peers analysis show that there has been no measurable shift in truck traffic from I-80 (Parley's Canyon) to US-189 (Provo Canyon) during the construction impacts of I-15. However, based on truck driver attitudes, it does appear that continued improvements to Provo Canyon, as outlined in the SEIS, will result in diverted truck traffic from I-80 to US-189.

The magnitude of these diverted truck movements is projected to be approximately 200 additional heavy trucks per day in the design year (2020). This estimate is consistent with the 1989 SEIS, which projected 160 additional trucks per day in the year 2010 diverted from I-80 with the proposed improvements to US-189.

Induced Traffic

Primarily in urban areas, there is a growing national concern that expansions in transportation infrastructure create proportionate increases to transportation demand. The theoretical basis for the concept of induced travel follows from economic principles of supply and demand, where reductions in travel time result in new supply curves, which intersect with fixed demand at a higher value (of vehicle miles). The practical application for this concept might be that people in Wasatch County are more willing to seek jobs in Utah County if travel time between the counties (via US-189) is reduced, which would result in greater traffic through Provo Canyon without a corresponding higher level of population or employment.

Induced traffic was not a consideration of the 1978 EIS, 1989 SEIS, or 1995 environmental re-evaluation. Fehr & Peers reviewed several technical papers on the subject of induced travel, all based on research in urban areas. While no single methodology exists for estimating induced travel, most of the literature points to short term inelastic relationships between travel time and travel demand. In the longer term, there appears to be some evidence that elasticities of travel demand with respect to travel time can be as high as 6 percent. Therefore, based on the off-peak travel time improvement projected with improvements to US-189, induced travel will likely increase traffic volumes in the year 2020 by between approximately 1000 to 1300 vehicles per day, or 6 percent of the forecast daily traffic volume. The impact will also be felt in the design hour resulting in a high end forecast of approximately 170 additional vehicles.

Safety

A review of crashes and fatalities was developed as part of this traffic analysis. One of the primary reasons for road improvements is to produce a corresponding increase in safety, which can be measured by reductions in traffic crashes and fatalities. Annual accident data since 1990 shows that while the accident and fatality rates have decreased slightly, the numbers on US-189 remain relatively unchanged. Due to the construction impacts on the road, it is difficult to determine if the proposed safety improvements are producing positive safety results. Fehr & Peers supports safety improvements proposed as part of the SEIS and anticipates that accident reductions will follow from the package of recommended improvements, which include access control, standard lane widths and shoulders, improvements to design speeds at curves, and elimination of driver frustration due to bottlenecks and delays.

It is important to highlight that the level of traffic fatalities is a greater concern than the level of overall crashes. Alternative improvements such as a shared passing lane for each direction of travel (depending on the location of upgrades) may not solely provide for the safety improvements envisioned.

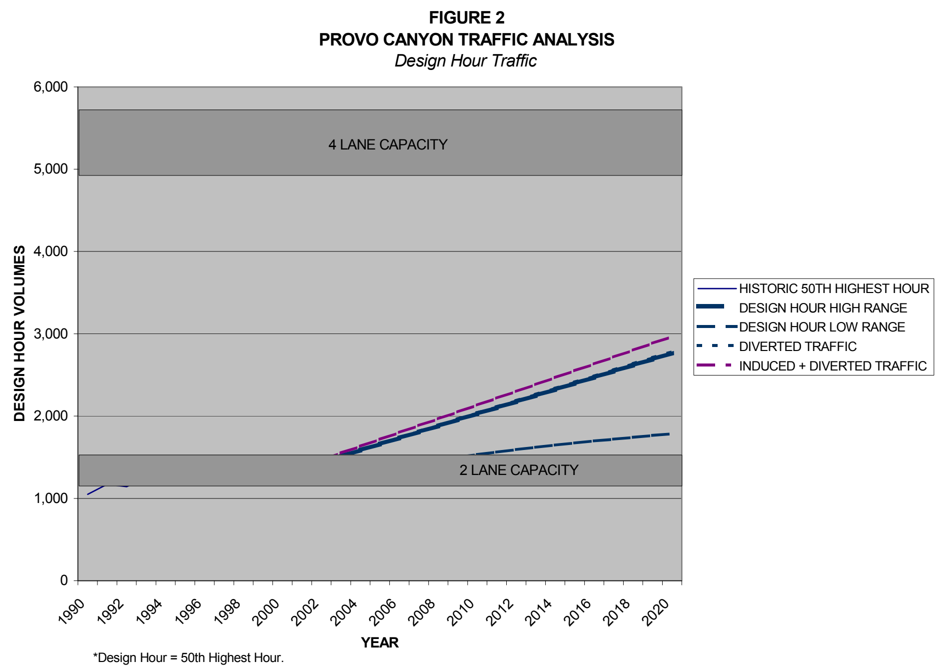


Figure 2: Comparison of Design Hour traffic volume and traffic capacity.

<u>Traffic Capacity</u>

Even though there is some error range in the ability to forecast future year traffic in Provo Canyon, it is clear that the present two lane cross section is inadequate. Fehr & Peers analyzed traffic capacity based on the forecast design hourly volume, and included trends that reflect the fact that the 50^{th} highest hour volume has been decreasing as a percentage of AADT (the 50^{th} highest hour volume is still increasing, but not as fast as the AADT). Based on this analysis, the level of service in the critical sections (generally below the Deer Creek Dam) on US-189 is arguably failing during peak periods today and will reach more chronic failure conditions by the year 2009, well within the design year (year 2020).

With a proposed four-lane cross section, level of service will remain within an acceptable range throughout the design year, even if traffic increases are considered based on diverted and induced trips. A detailed analysis of alternative improvements, such as a three-lane section, has not been performed. Due to the variation of travel direction within the top 100 travel hours as well as the rolling nature of the steep grades (as opposed to long sustained upgrades and subsequent downgrades), it does not appear that a three lane section could achieve either the capacity or safety benefits of the proposed four lane section. A summary of design hour traffic growth, inclusive of diverted and induced trips, compared with existing and proposed traffic capacity of Provo Canyon is shown in Figure 2. Note that capacities shown estimate maximum capacity of a 2 lane or 4 lane section. It is desirable to achieve level of service C in rural areas, which typically occurs at 50 to 85 percent of maximum capacity.

<u>Changes Since Earlier Analyses</u>
As discussed, traffic in Provo Canyon has been analyzed for many years, with environmental documents completed in 1978, 1989, and 1995. An important component of this most recent effort, in addition to re-evaluating historic data and developing independent conclusions, is to consider more recent data and to identify changes in traffic conditions or traffic related conclusions. To this end, the following bullets highlight changes reflected in this recent analysis that do not appear to be included in previous analysis:

- Induced traffic has been estimated and results in a small fraction of overall traffic.
- Diverted traffic has been estimated by a recent survey and may be slightly higher than the 1989 SEIS, but still remains a very small number.
- Design hourly volumes continue to be based on the 50th highest hour, but this hour has been decreasing as a percent of average daily traffic.

The overall conclusion related to the inability of the existing road to accommodate the expected growth of traffic remains valid. Further, the improvements proposed in the earlier analyses appear to be necessary.

TABLE OF CONTENTS

I. PROJECT BACKGROUND

A. History

Planning efforts to improve US-189, Provo Canyon, have been in progress for almost 25 years. An Environmental Impact Statement (EIS) was first prepared in 1978, which resulted in a recommendation to widen and improve the canyon road to a two-lane roadway with continuous passing lanes from US-89 in Orem to US-40 in Heber. A civil action was filed in 1986 resulting in the preparation of a Supplemental EIS in 1989. Various improvements, which are consistent with the 1989 SEIS, were implemented beginning in 1991. The improvements began at the lower section of the project (near US-89 in Orem) and have progressed northward. At present, the project has been completed from the Murdock Junction to Vivian Park. Improvements from Vivian Park to Wildwood are underway, and design (and an environmental re-evaluation) has been completed from Wildwood to Deer Creek State Park. The final section from Deer Creek State Park to Heber remains at the conceptual level.

B. Scope

The purpose of this report is to review the overall demand for roadway improvements and to identify traffic issues that may have changed since earlier analyses. While a comprehensive traffic analysis was prepared for each of the earlier environmental studies, some question remains regarding whether more recent data, which may alter earlier conclusions, may reflect new trends. In particular, past construction activities related to alternative routes could be considered in a longer time series analysis to determine whether traffic growth is explained by diversions of regional trip making. Similarly, the concept of induced growth has not been formally embraced by most traffic forecasting agencies but reflects a growing concern of the “sustainable development” movement. In addition to these specific concerns of induced and/or diverted traffic, the scope of this traffic analysis is generally to review the available data on traffic in Provo Canyon and to develop independent conclusions regarding the adequacy of planned improvements from a traffic safety and capacity standpoint.

C. Purpose of This Review

Although coordination has occurred between UDOT Planning, UDOT Region 3, and BioWest (the consultant performing the SEIS) in the development of this report, it is intended as a stand-alone traffic analysis. Certain conclusions may be summarized or re-worded for inclusion in the SEIS, but the NEPA format of identifying Purpose and Need, Identifying and Evaluating Alternatives, etc. has not been followed. Further, no public involvement was solicited for the development of this analysis. Only numerical trends of traffic safety and capacity were identified in order to assist UDOT in defining and quantifying traffic-based needs. Part of the environmental process for the SEIS is to identify impacts associated with meeting traffic needs and to reach appropriate conclusions as to whether a no-build or various alternative-build improvements may be desirable. This report does not consider trade-offs or value judgments regarding the need to provide for adequate traffic flow and traffic safety.

II. TRENDS

A. Socio-Economic Conditions

Socio-economic data was used from both Utah and Wasatch Counties in order to predict the future values of average annual daily traffic (AADT) for the canyon. Utah and Wasatch County Population and Employment data were gathered from three different sources. All Population and Employment numbers come from the Demographic and Economic Analysis, prepared by the Governor's Office of Planning and Budget (GOPB)[1]. The 1975 thru 1989 Population and Employment values come from the "The State of Utah Economic & Demographic Projections-1994"[2]. The 1990 to 1998 Population and Employment numbers come from The Data Table for 1990-1998[3]. These numbers were used to show changes in population and employment from 1975 to the present. The values then predict the future growth of both Utah and Wasatch County. A population and employment figure is for Utah and Wasatch Counties can be seen in Table 1.

<u>Recreational Generators</u>

Provo Canyon experiences recreational traffic, especially in the peak summer months. The exact number of recreational trips is not easily quantified because available data represents reservation guests only, and does not give a clear picture of all recreational trips to major attractions such as:

- Provo River Campground
- Sundance Resort
- The Timpanogas Wilderness Trails and Campgrounds
- Deer Creek Reservoir State Park
- Jordanelle Reservoir State Park

B. Traffic Growth Trends

The (AADT)[4] was compared to Utah and Wasatch County population and employment growth from 1975 to the present day. Figure 1 displays normalized growth in traffic as compared to growth in population and employment. Traffic growth strongly mirrors the socio-economic (population and employment) trends of adjacent counties. The traffic decrease in 1997 was likely due to construction impacts and short duration road closures in the canyon. It appears that traffic growth is strongly tied to socio-economic growth of the adjacent counties, and is relatively unaffected by short-term impacts on parallel routes (such as the recent and on-going re-construction of I-15 in Salt Lake County or the prior upgrade of US-40 in Summit and Wasatch Counties).

---

[1] State of Utah Long Term Economic and Demographic Projections, Governor's Office of Planning and Budget UPED Model System, December 13, 1999.
[2] State of Utah Economic and Demographic Projections, 1994, Governor's Office of Planning and Budget, September 1994, page 389.
[3] State of Utah Economic and Data Table for 1990-1998, Governor's Office of Planning and Budget.
[4] Traffic Capacity Study for U.S. 189, Wildwood to Deer Creek State Park, Centennial Engineering, page 3, and recent traffic data collected by UDOT at Mile Marker 11.17.

TABLE 1

PROVO CANYON TRAFFIC ANALYSIS

Population and Employment for Utah and Wasatch Counties.

Utah County

Year	Population	Employment
1975	176,800	48,850
1976	184,700	52,380
1977	193,700	56,030
1978	203,100	61,320
1979	211,500	64,790
1980	220,000	63,820
1981	227,000	64,060
1982	232,000	63,900
1983	238,000	64,310
1984	243,000	68,060
1985	245,000	70,145
1986	247,000	72,477
1987	252,000	74,479
1988	255,000	81,393
1989	258,000	87,049
1990	266,000	111,322
1991	272,000	116,743
1992	279,000	119,342
1993	291,000	128,518
1994	299,000	138,568
1995	307,741	139,135
1996	317,881	145,422
1997	330,803	149,720
1998	340,816	153,702
1999	353,123	183,880
2000	361,213	189,386
2001	369,236	194,647
2002	377,084	198,244
2003	385,793	202,781
2004	395,972	207,941
2005	408,220	214,465
2006	420,142	220,933
2007	432,918	227,668
2008	445,230	234,263
2009	457,987	240,980
2010	469,691	247,153
2011	480,705	253,089
2012	491,686	258,902
2013	501,956	264,409
2014	511,756	269,710
2015	520,353	274,569
2016	528,487	279,187
2017	536,384	283,630
2018	544,154	287,972
2019	551,955	292,279
2020	559,907	296,602

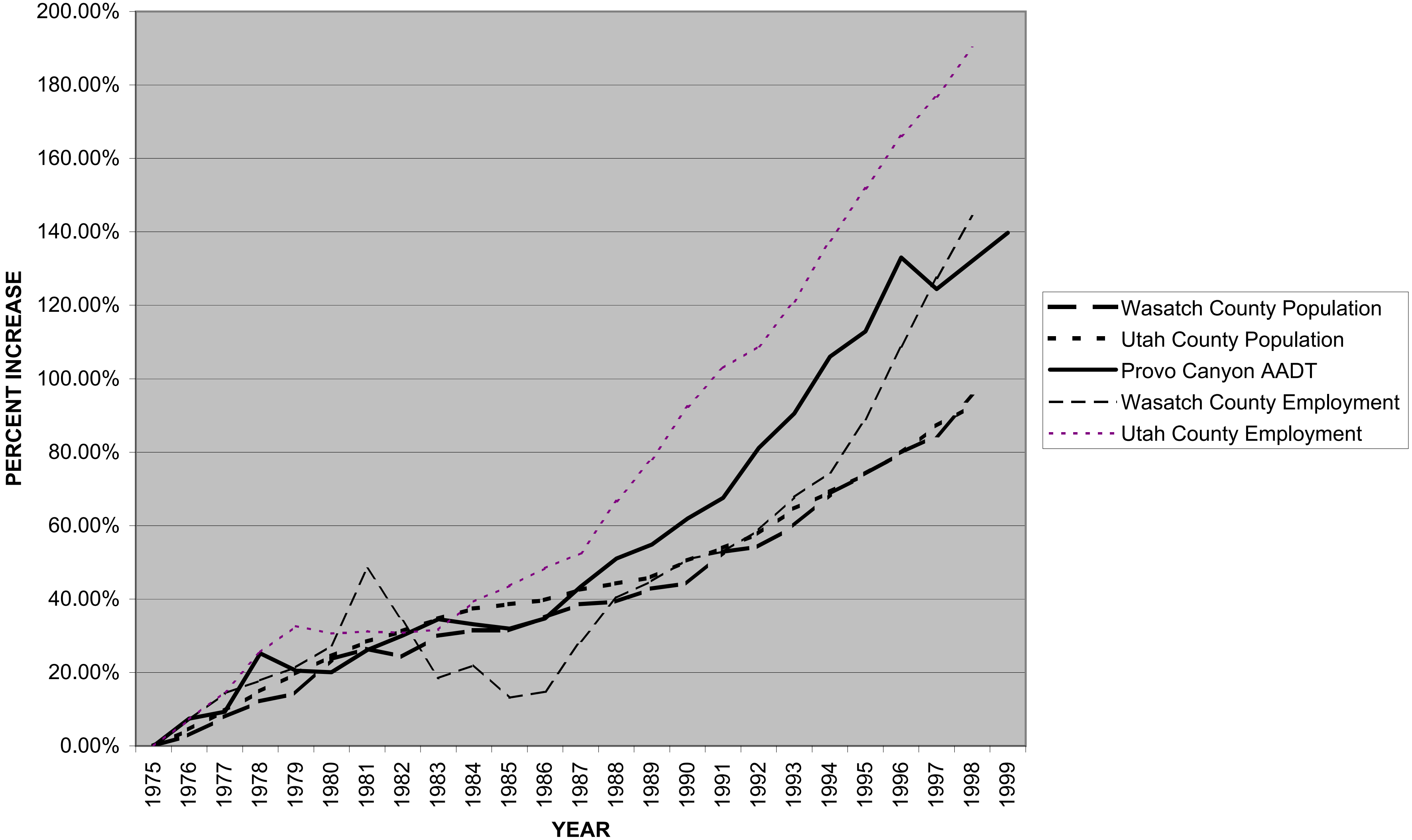
Wasatch County

Year	Population	Employment
1975	7,000	1,680
1976	7,200	1,800
1977	7,550	1,920
1978	7,850	1,980
1979	8,000	2,040
1980	8,650	2,140
1981	8,850	2,490
1982	8,700	2,250
1983	9,100	1,990
1984	9,200	2,050
1985	9,200	1,900
1986	9,450	1,928
1987	9,700	2,160
1988	9,750	2,358
1989	10,000	2,434
1990	10,100	4,239
1991	10,700	4,201
1992	10,800	4,340
1993	11,200	4,646
1994	11,800	4,981
1995	12,179	4,949
1996	12,585	5,257
1997	12,925	5,496
1998	13,653	5,710
1999	13,710	6,501
2000	14,111	6,720
2001	14,538	6,956
2002	14,980	7,140
2003	15,464	7,366
2004	15,997	7,602
2005	16,615	7,888
2006	17,223	8,181
2007	17,868	8,477
2008	18,497	8,774
2009	19,148	9,074
2010	19,758	9,356
2011	20,342	9,623
2012	20,926	9,891
2013	21,479	10,144
2014	22,015	10,387
2015	22,504	10,624
2016	22,972	10,845
2017	23,431	11,061
2018	23,885	11,269
2019	24,342	11,484
2020	24,806	11,691

* All data up to 1998 gathered from Demographics and Economic Analysis, Govenor's Office of Planning and Budget, 1980 and 1990 populations are April 1 U.S. Census MARS populations; all others are July 1 populations.

*1999 to 2020 values from The State of Utah Long Term Economic and Demographic Projections from, Govenor's Office of Planning and Buget.

FIGURE 1
PROVO CANYON TRAFFIC ANALYSIS
Population and Employment Growth Since 1975



Employment and Population Data Sets from Utah and Wasatch Counties were compared with AADT. This was done using Pearson's Product-Moment Correlation Coefficients (r). "Pearson's r is probably the most widely used correlation coefficient for interval/ratio level data. Like other association coefficients, it measures the extent to which the same individuals (objects, events, etc.) have the same relative scores on two variables."[5] Using a scattergram then to plot the data points a linear line is then used to correlate all of the values and the resulting R^2 value determines how directly the variables correlate. The value of the R^2 determines whether a relationship between variables exists. A value of zero for the R^2 value shows that there is no clear relationship between variables. The strongest correlations are those that have a R^2 value close to one. Figure 2 shows the relationship between the AADT and population, which is compared at an R^2 value of .9675. Figure 3 shows the relationship of AADT and employment in Utah County, which has a resulting R^2 value of .9627. Figure 4 compares Utah County Population and AADT, with a resulting R^2 value of .9511. Figure 5 compares Wasatch County employment with AADT, and shows a resulting R2 value of .923. All resulting values indicate of an extremely strong correlation between traffic, population and employment.

Traffic projections prepared in the 1978 EIS and 1989 SEIS were based on a trend analysis of past traffic growth and resulted in a projected growth rate of between 3.2 percent and 3.7 percent annual growth to the year 2010. The 1995 environmental re-evaluation based traffic growth on both a trend analysis and a linear regression of regional (five county) population. The environmental re-evaluation forecast traffic growth between 1.3 percent and 1.6 percent annually. In 1994 the projected values of population for Utah County in 2010 were 407,438[6] compared to the 1998 projections of 469,691[7]. The projected values of population for Wasatch County in 2010 were 15,953[8] compared to the 1998 projections of 19,758[9]. This explains why the low end traffic forecast of 10,863 AADT projected for the year 2010 (using the 1.3 percent annual growth) was almost passed by year 2000 traffic counts (10,285 AADT). The present analysis based traffic on population and employment forecasts in Utah and Wasatch Counties, which resulted in a forecast growth rate of between 2.2 percent and 3.4 percent average annual growth to the year 2020. It can be concluded that average daily traffic will continue to grow similarly to the growth of population and employment of the adjacent counties. According to forecasts published by the Utah Governor's Office of Planning and Budget, both counties are projected to continue with high growth for the foreseeable future.

[5] Basic Social Statistics, Leonard, 1985, pg. 318.
[6] State of Utah Economic and Demographic Projections, 1994, Governor's Office of Planning and Budget, September 1994, page 389.
[7] State of Utah Economic and Data Table for 1990-1998, Governor's Office of Planning and Budget.
[8] State of Utah Economic and Demographic Projections, 1994, Governor's Office of Planning and Budget, September 1994, page 389.
[9] State of Utah Economic and Data Table for 1990-1998, Governor's Office of Planning and Budget.

Impacts of Construction

Since 1989 the State of Utah has experienced much growth in population. Many construction projects around the state are evidence of an effort to accommodate this growth, however, there is no notable increase in traffic as a result of construction projects. All traffic in Provo Canyon can be explained from the growth in population and employment in both Wasatch and Utah Counties. The only result of traffic during or after construction was when Provo Canyon was temporarily closed and then reduced to a single alternating lane because of a rockslide. A record of construction activity is listed below.

- The I-15 Project began May 12, 1997,
- Provo Canyon improvements from 1990 to 1998,
- US 40 was relocated,
- University Avenue was reconstructed, and;
- Parley's Canyon was resurfaced.

FIGURE 2
PROVO CANYON TRAFFIC ANALYSIS
WASATCH COUNTY AADT VS. POPULATION

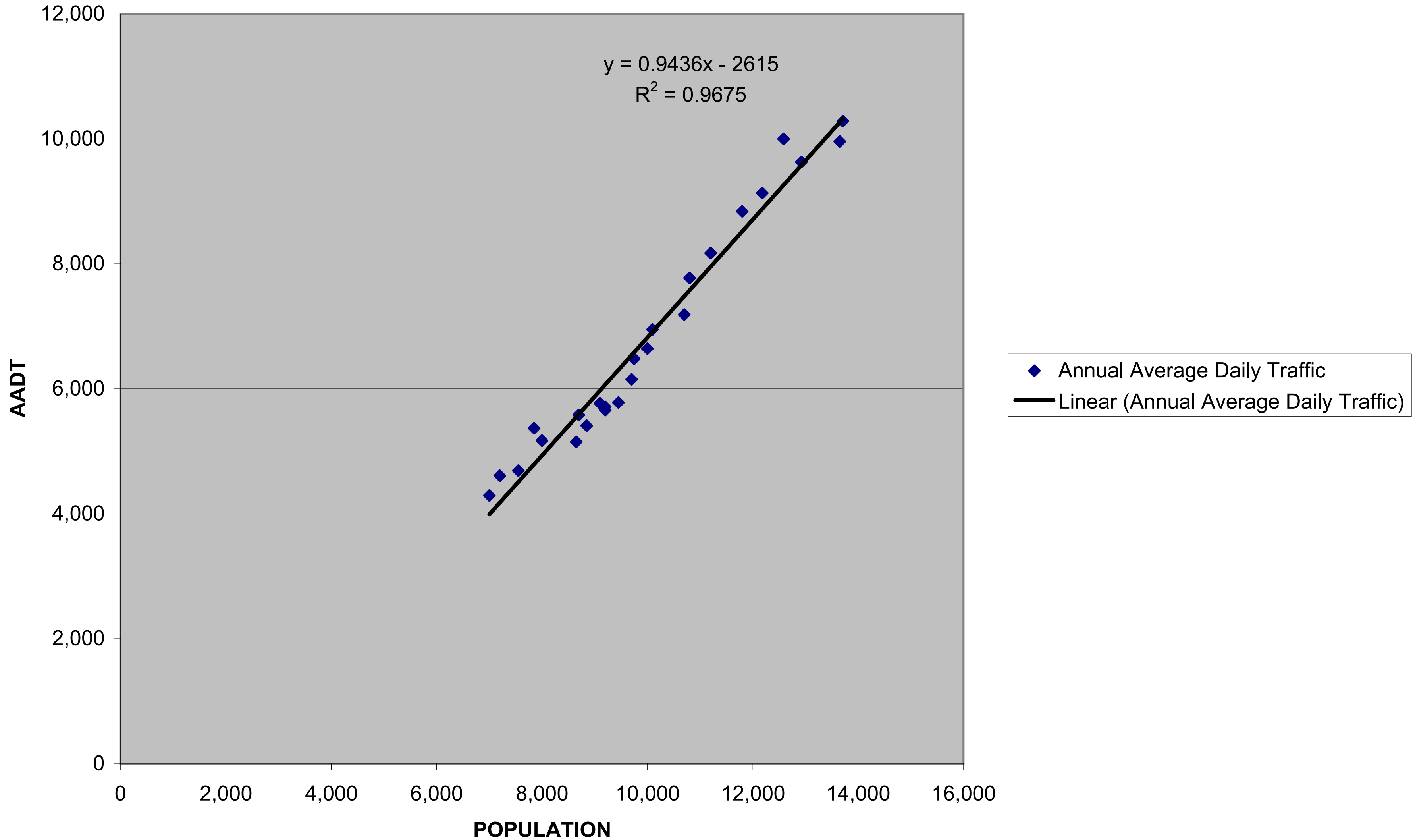


FIGURE 3
PROVO CANYON TRAFFIC ANALYSIS
UTAH COUNTY AADT VS. EMPLOYMENT

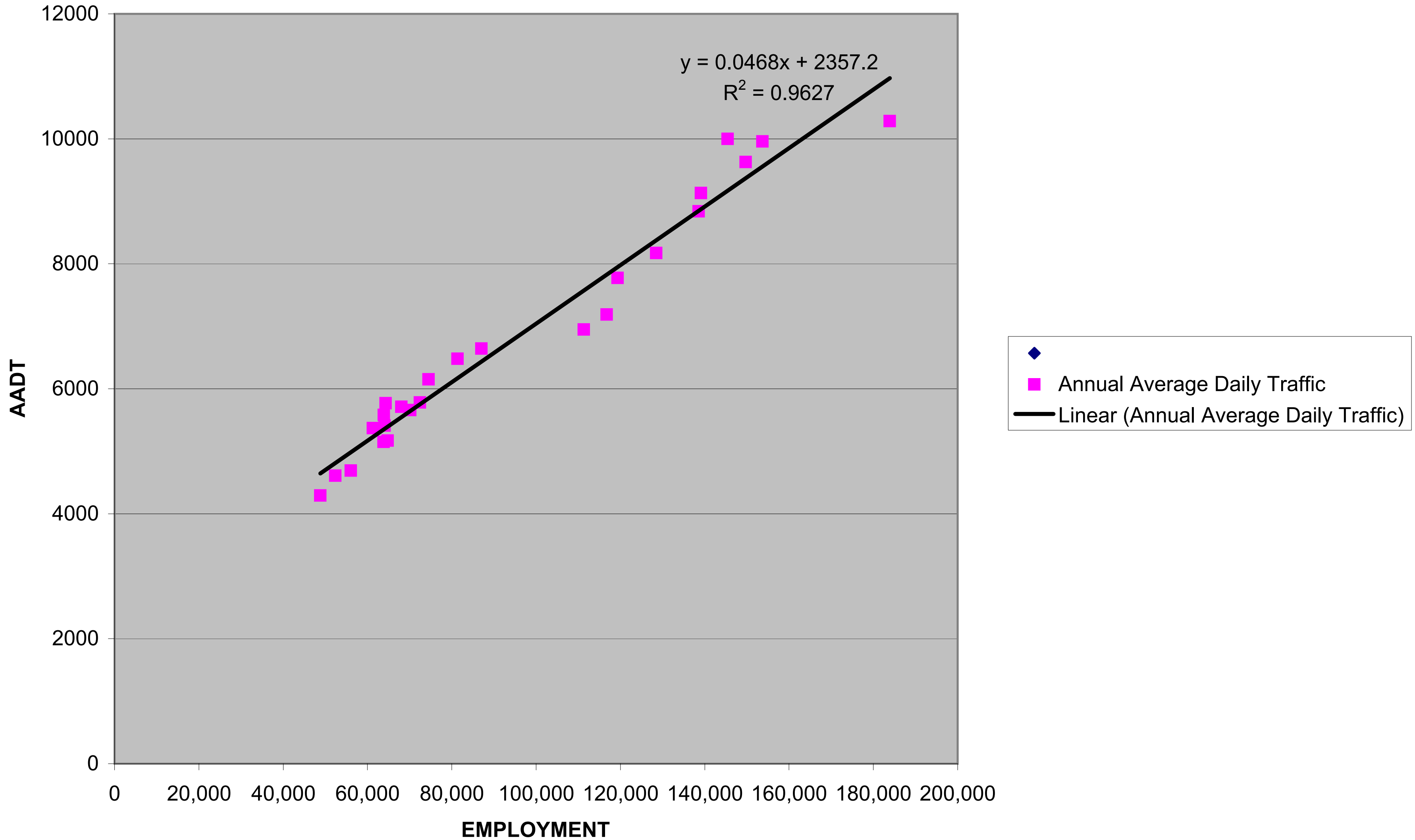


FIGURE 4
PROVO CANYON TRAFFIC ANALYSIS
UTAH COUNTY AADT VS. POPULATION

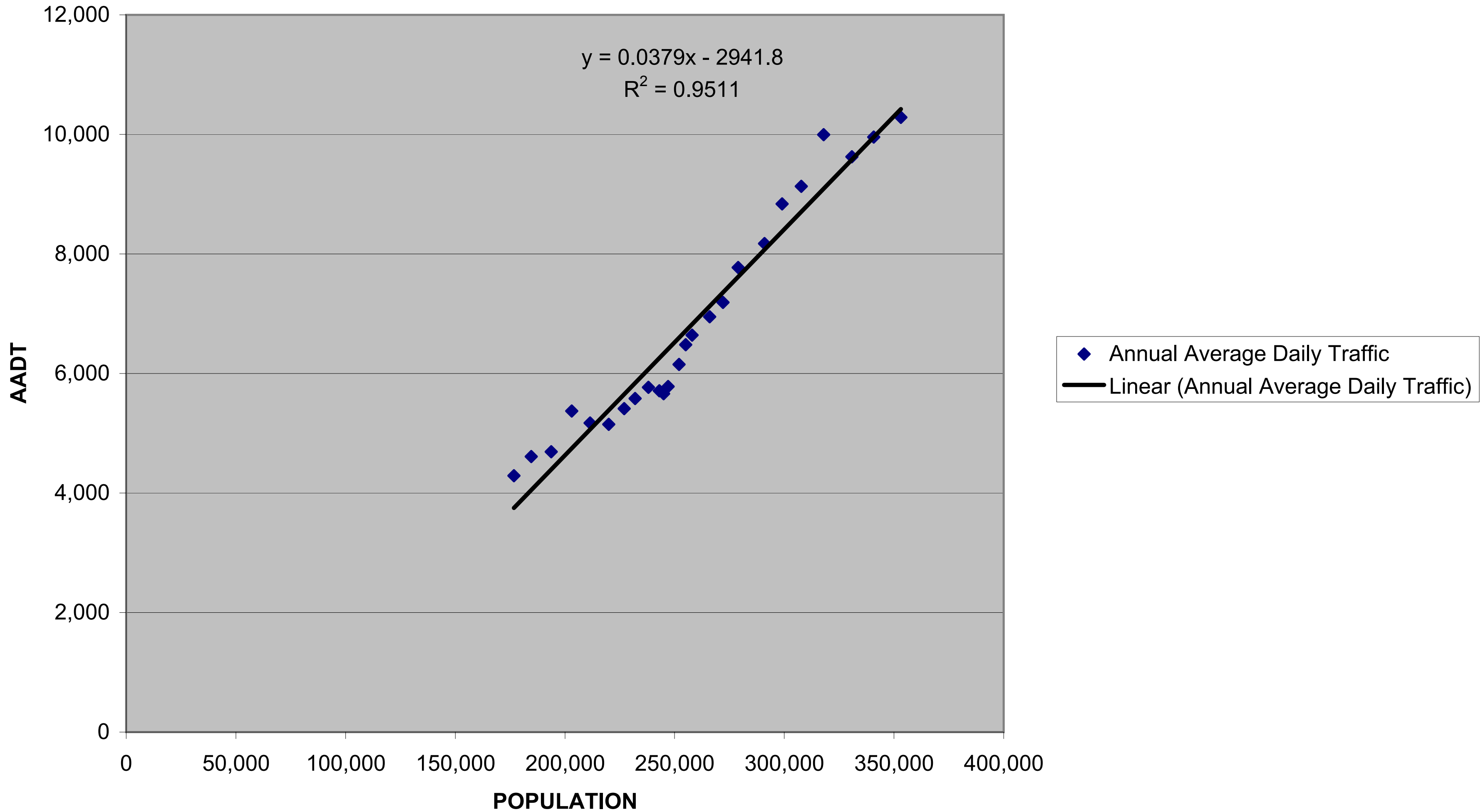
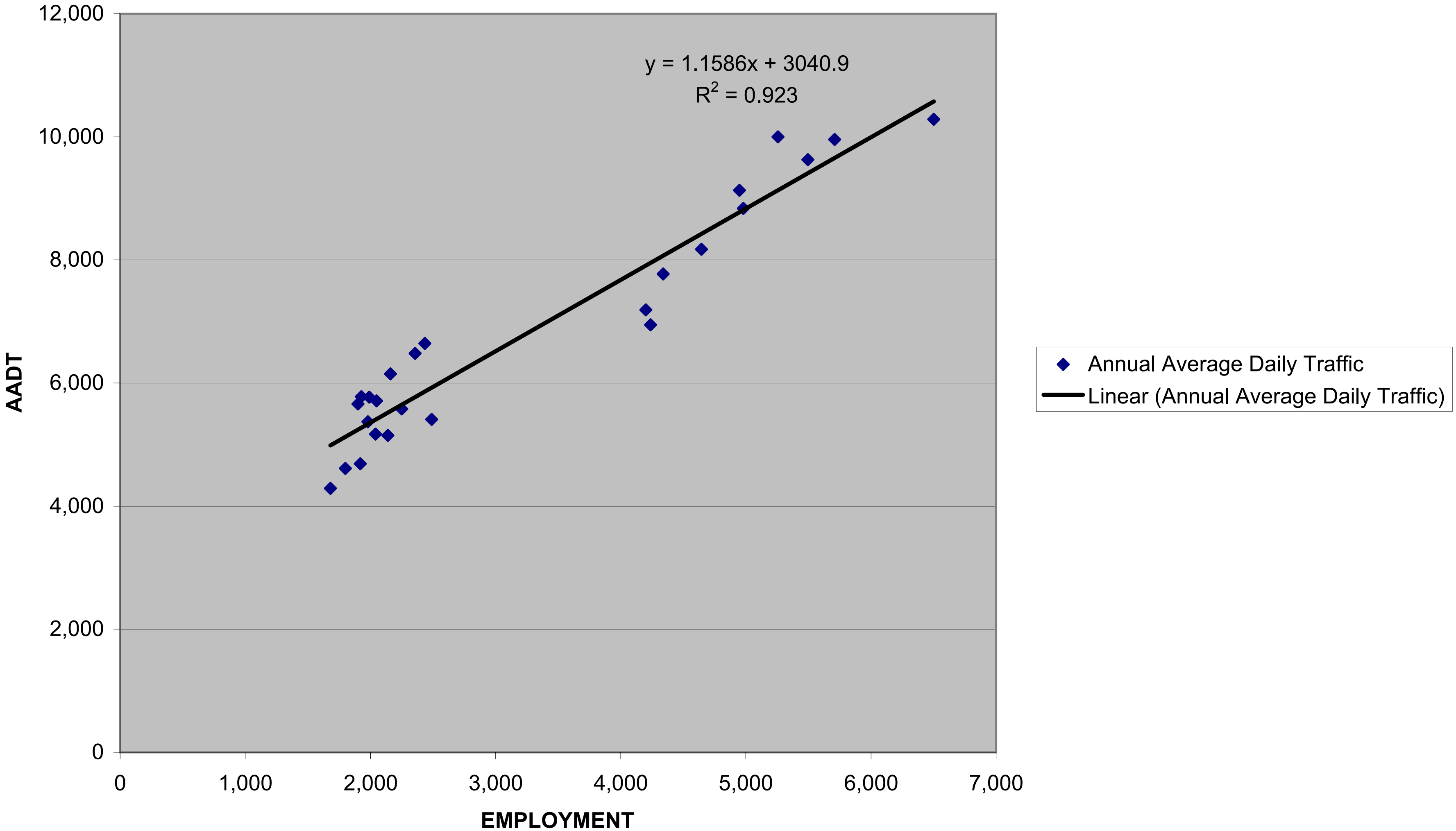


FIGURE 5
PROVO CANYON TRAFFIC ANALYSIS
WASATCH COUNTY AADT VS. EMPLOYMENT



<u>Changes Since Earlier Analyses</u>

As discussed, traffic in Provo Canyon has been analyzed for many years, with environmental documents completed in 1978, 1989, and an environmental re-evaluation in 1995. An important component of this most recent effort, in addition to re-evaluating historic data and developing independent conclusions, is to consider more recent data and to identify changes in traffic conditions which would change previously made conclusions. The conclusion of the inability of the existing road to accommodate expected growth of traffic remains valid. Further, the improvements proposed in the earlier analyses appear to be necessary. However, the following bullets highlight changes reflected in this recent analysis that do not appear to be included in previous analysis:

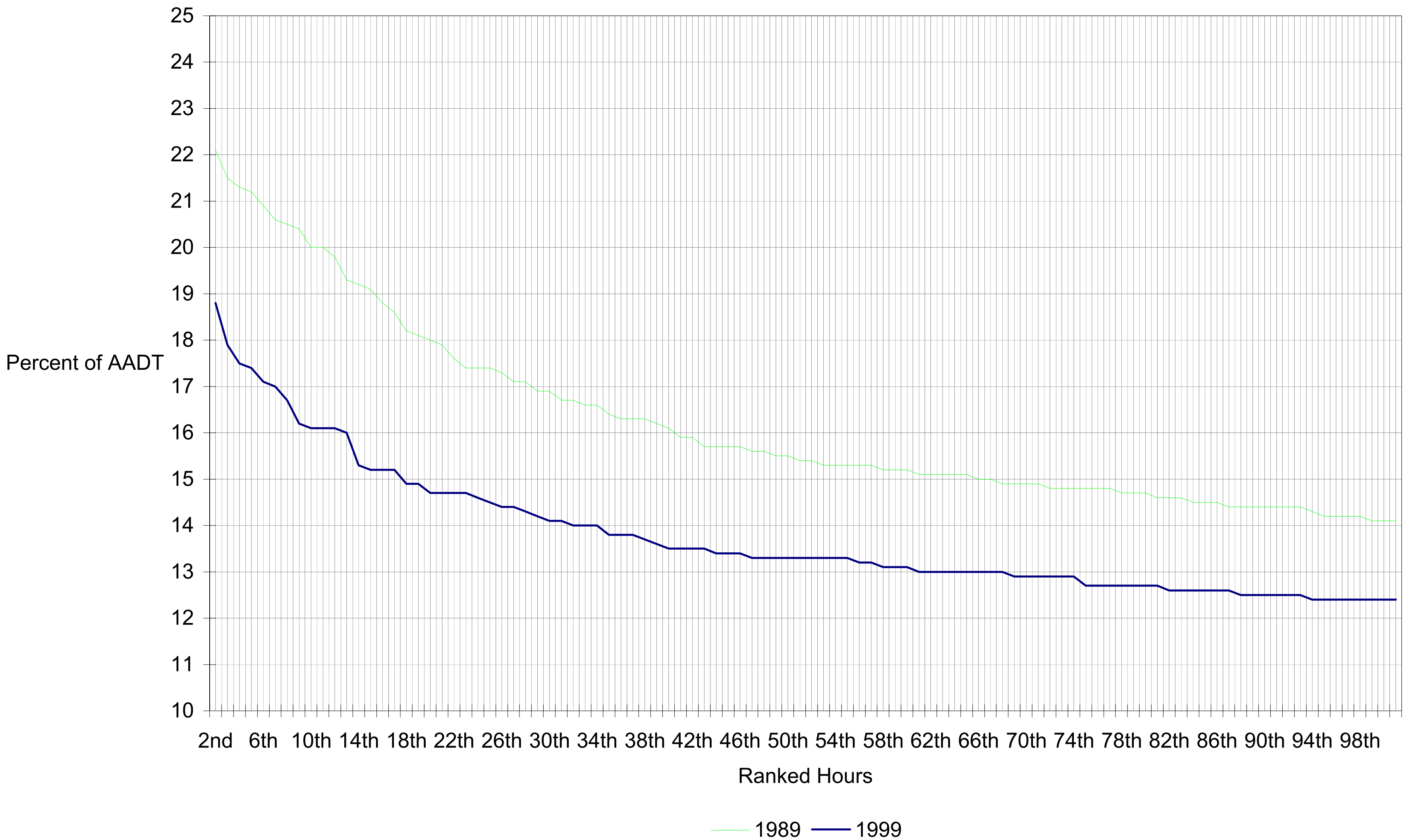
- Induced traffic results in a small fraction of overall traffic.
- Diverted traffic, which has been estimated by a recent survey, is slightly higher than the 1989 SEIS, but remains a very small number.
- Design hourly volumes continue to be based on the 50th highest hour. This hour has been decreasing as a percent of average daily traffic.

<u>Design Hour</u>

A standard practice to determine the design hour volume is to plot the 100 highest hourly volumes as a percentage of AADT and identify a 'turning point" in the curve. "Customary practice in the United States is to base rural highway design on an hour between the 30th- and 100th- highest hour of the year. This range generally encompasses the "knee" of the curve: the area in which the slope of the curve changes from sharp to flat."[10] Traditionally Provo Canyon functions as a recreational facility. "Use of a design criterion set at the 100th hour would created substantial congestion on a recreational access route during the highest-volume hours but would have less effect on an urban facility, where the variation in peak-hour volumes is less."[11] Figure 6 illustrates the plot of the 100 highest hourly volumes as a percentage of AADT for 1989 & 1999. The plot show that the rate of decrease begins to lessen at the 30th highest hour. However, the rate of decrease is almost constant from the 50th to the 100th highest hour, a change of only .9 percent between the 50th and 100th highest hour. This indicates that the 50th highest hourly volume closely represents the 50th through 100th highest hour. Therefore the 50th highest hour of 13.3 percent of the AADT in 1999 will be applied to the AADT to determine the actual design hour volume. The plots also indicate that while the AADT increases, the percentage of hourly traffic volume to the AADT has decreased.

[10] Traffic Engineering Handbook, 5th edition, Institute of Transportation Engineers, 1999, pg. 109-110.
[11] Traffic Engineering Handbook, 5th edition, Institute of Transportation Engineers, 1999, pg. 110.

FIGURE 6
PROVO CANYON TRAFFIC ANALYSIS
100th Hours hourly Volumes SR-189 at Bridal Veil Falls



Seasonal Variation

At the present time Provo Canyon US-189 experiences traffic fluctuations as a result of recreational uses. Future economic growth in Utah and Wasatch Counties will lessen this traffic fluctuation. The traffic volumes in January and February are almost half of the volumes experienced in July and August. This seasonal variation could be a result of precarious conditions that occur during the winter months throughout the canyon. The high rates in the summer time are indicative of extensive seasonal traffic for recreational activities throughout the canyon. Seasonal variation has not changed from the initial study values that represent 1975-1988 volumes. Figure 7 shows the seasonal number increase in value with an almost identical distribution.

Daily Variation

The daily variations are recorded in Figure 8 with the 1999 daily numbers from the UDOT permanent count station at Bridal Veil Falls, Mile Marker 11.17. The daily variations support that this highway acts as a recreational road because the values for Friday and Saturday are much higher than the rest of the week. The highest daily volumes come from Saturday volumes in July and August.

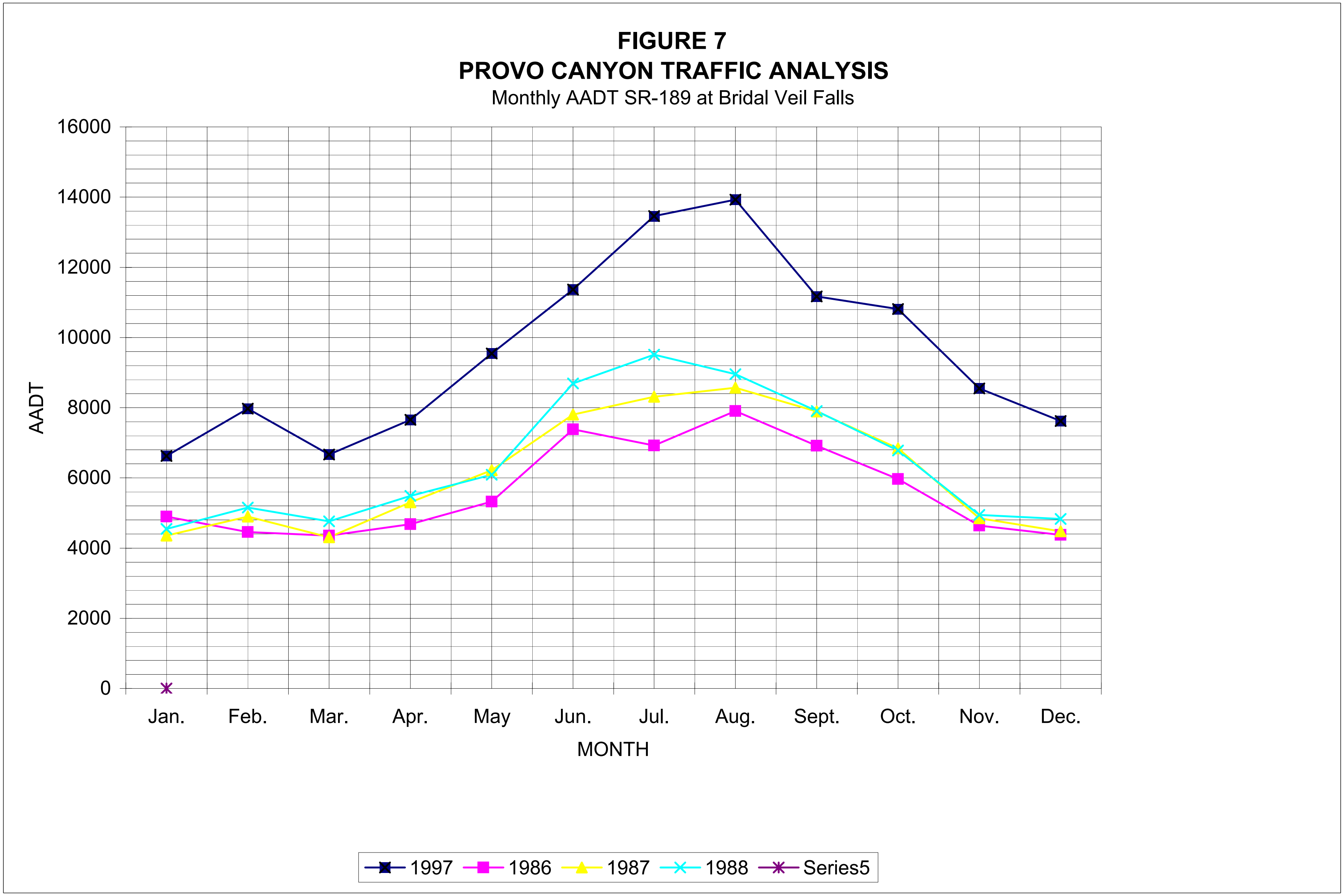


FIGURE 7
PROVO CANYON TRAFFIC ANALYSIS
Monthly AADT SR-189 at Bridal Veil Falls
16000
14000
12000
10000
8000
6000
4000
2000
0
AADT
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sept.
Oct.
Nov.
Dec.
MONTH
1997
1986
1987
1988
Series5

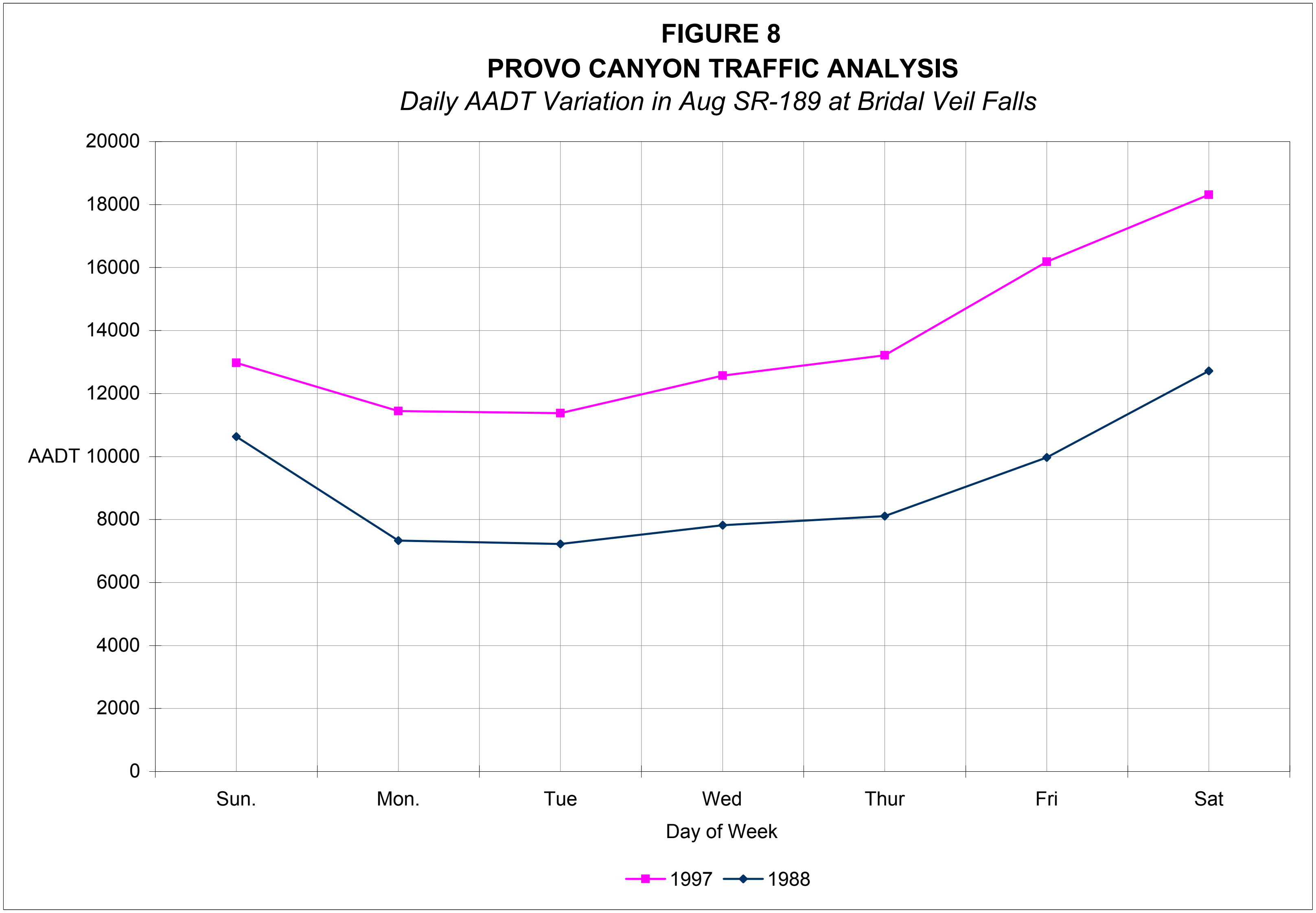


FIGURE 8
PROVO CANYON TRAFFIC ANALYSIS
Daily AADT Variation in Aug SR-189 at Bridal Veil Falls
AADT
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Sun.
Mon.
Tue
Wed
Thur
Fri
Sat
Day of Week
1997
1988

III. TRAFFIC FORECASTS

A. "Best Practice" Model

An accepted practice in forecasting traffic is to use a four-step travel demand model. However, Provo Canyon lies outside of the boundaries of an existing urban traffic demand model. Therefore, relationships between recent traffic counts and socio-economic variables were studied and compared against other trends in order to forecast an 2020 AADT.

B. Trend Analysis

Best Fit Regression

The 2020 AADT values for Provo Canyon were determined by plotting the best-fit regression charts shown in Section II. B. Since this correlation between variables is so strong between the R^2 values the same method was used to forecast the future AADT using the Utah and Wasatch County population and employment forecasts from the Governor's Office of Planning and Budget. The predicted AADT was calculated by inputting the appropriate forecasted number to solve the equation. From this point a range of AADT's were calculated. Table 2 shows these predicted AADT's.

TABLE 2
PROVO CANYON TRAFFIC ANALYSIS
Predicted AADT From Socio-Economic Data

Direct Variable	R^2 Value	Equation	2020 AADT
Utah County Population	.9511	Y=0.0379X-2941.8	18,279
Utah County Employment	.9627	Y=0.0468X+2357.2	16,238
Wasatch County Population	.9675	Y=0.9436X-2615	20,792
Wasatch County Employment	.923	Y=1.1586X+3040.9	16,586

1. Population and Employment values used from projections of Governor's Office of Planning and Budget.

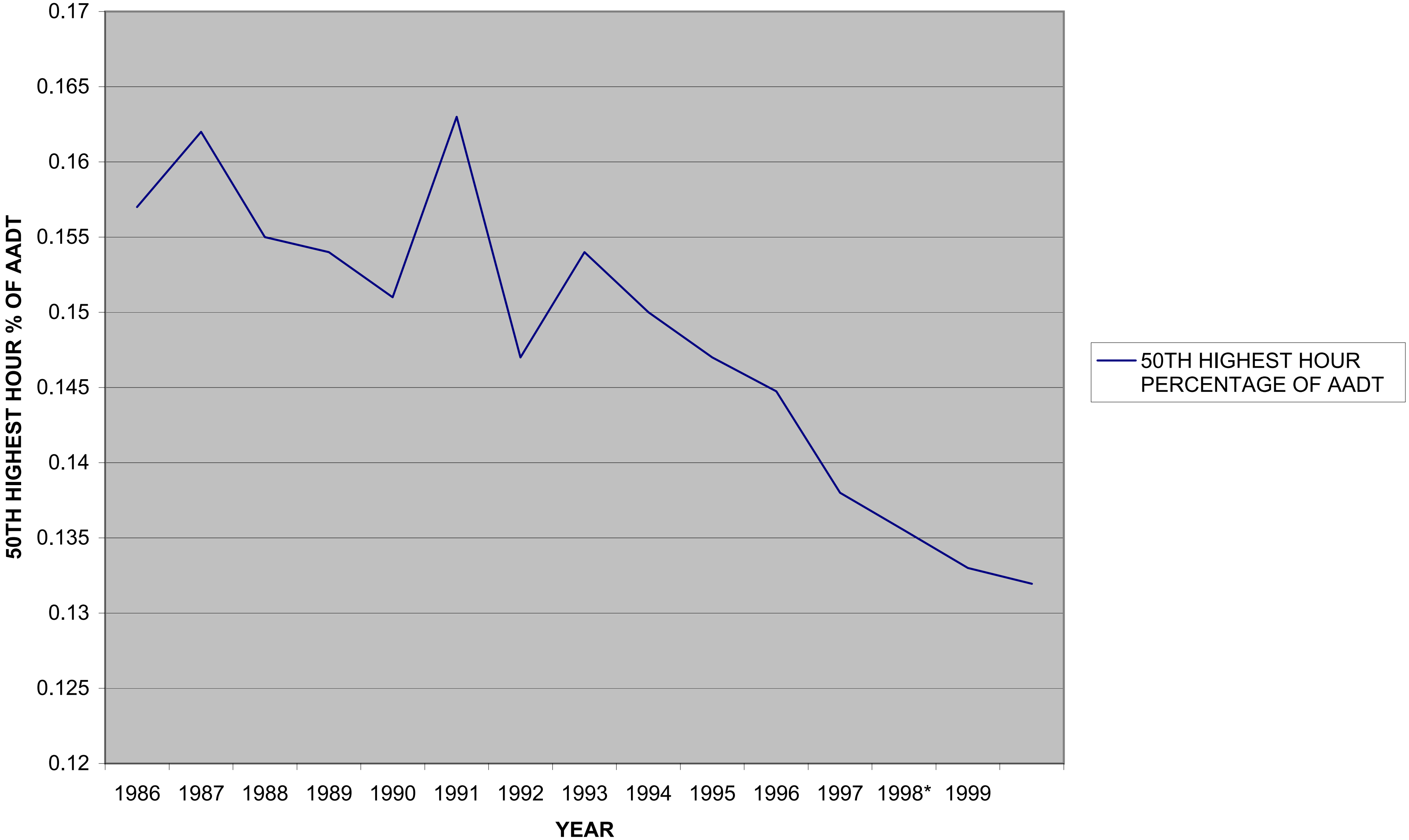
To account for the worse case scenario, the highest and lowest values for 2020 AADT were used respectively. This means that the highest daily value is 20,792 from the Wasatch County Population and the low value is 16,238 from the Utah County Employment.

Design Hourly Forecast

The 50th highest hour of 13.3% of the AADT in 1999 was applied to the AADT to determine the actual design hour volume. Figure 9 indicates that while the AADT increases, the percentage of hourly AADT is decreasing. Because the 50th highest hour percentage of AADT is decreasing, it was assumed that the percentage of AADT would decrease to 11.0% in 2020. This was done using the existing 13.3% value from 1999 and correlating it with a trend line, which resulted in a value of 11.0% in 2020.

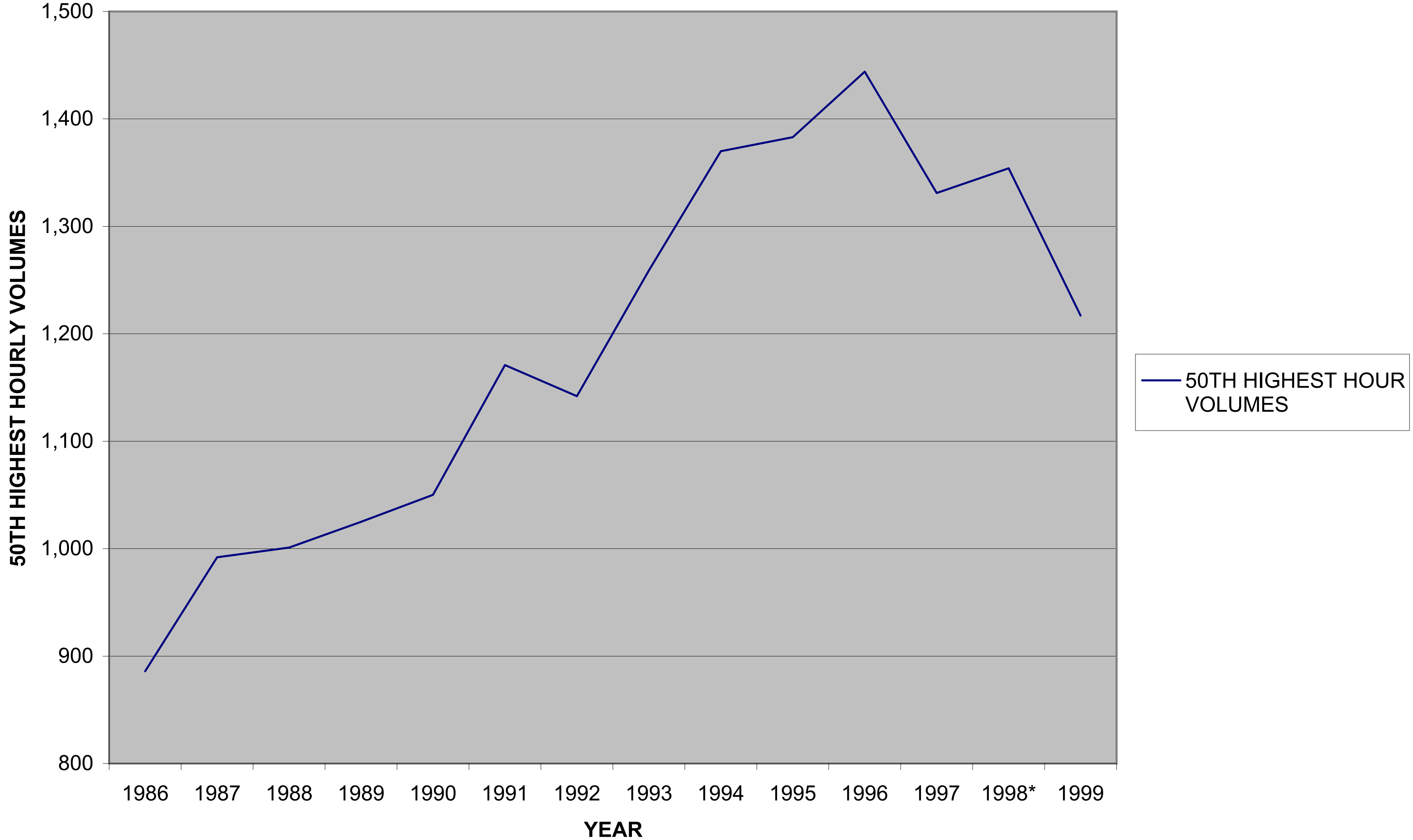
To calculate the highest possible hourly volume, the highest average daily traffic number, which is 20,792, was multiplied by 13.3 percent, which is the 50th highest hour percentile. To predict the lowest possible hourly volume that would occur in Provo Canyon, the Utah County population AADT was multiplied by 11.0%, which is the forecasted 50th highest hour percentile in 2020.

FIGURE 9
PROVO CANYON TRAFFIC ANALYSIS
50th Highest Hour Percentage of AADT



* - 1998 VOLUMES INTERPOLATED BECAUSE OF INSUFFICIENT COUNT STATION DATA

FIGURE 10
PROVO CANYON TRAFFIC ANALYSIS
50th Highest Hour Volumes



III. INDUCED TRAFFIC

A. Theory

DeCorla-Souza and Cohen defined induced traffic as: "increase in daily vehicle miles of travel (VMT), with reference to a specific geographic context, resulting from expansion of highway capacity".

Primarily in urban areas, there is a growing national concern that increases to transportation supply create direct increases to transportation demand. The theoretical basis for this concept of induced travel follows from economic principles of supply and demand, where reductions in travel time result in new supply curve which intersects with fixed demand at a higher value (of vehicle miles). The practical application for this concept might be that people in Wasatch County are more willing to seek jobs in Utah County if travel time between the counties (via US-189) is reduced, resulting in greater traffic on Provo Canyon without a corresponding greater level of population or employment.

B. National Research

Induced traffic was not a consideration of the 1978 EIS, 1989 SEIS, or 1995 environmental re-evaluation. Fehr & Peers reviewed several technical papers on the subject of induced travel, all based on research in urban areas. While no single methodology exists for estimating induced travel, most of the literature points to short-term inelastic relationships between travel time and travel demand. In the longer term, there appears to be some evidence that elasticities of travel demand with respect to travel time are in the range of 0.4 to 0.6.

Fehr & Peers Associates reviewed different sources for induced traffic to determine a factor to determine the induced traffic for Provo Canyon. The paper titled, "A Statistical Analysis of Induced Travel Effects in the U.S. Mid-Atlantic Region", by Lewis M. Fulton, states that elasticity of VMT vs. lane miles to be (0.1 to 0.4) in the short run, and (0.5 to 0.8) in the long run. Since no lane mile data was gathered, for this project, the paper titled, "Testing for the Significance of Induced Highway Travel Demand in Metropolitan Areas", by Lawrence C. Barr, was used that predicted elasticity of VMT vs. travel time (0.2 to 0.3) in 4 years, (0.3 to 0.4) after 10 years, and (0.4 to 0.6) after 16 years. The induced traffic as a result of VMT in Utah and Wasatch Counties results in value less than .1%. Using the values of travel time instead of VMT calculations results in a higher number of induced traffic and will be used to calculate a high-end prediction for the induced traffic value.

C. Local Estimate

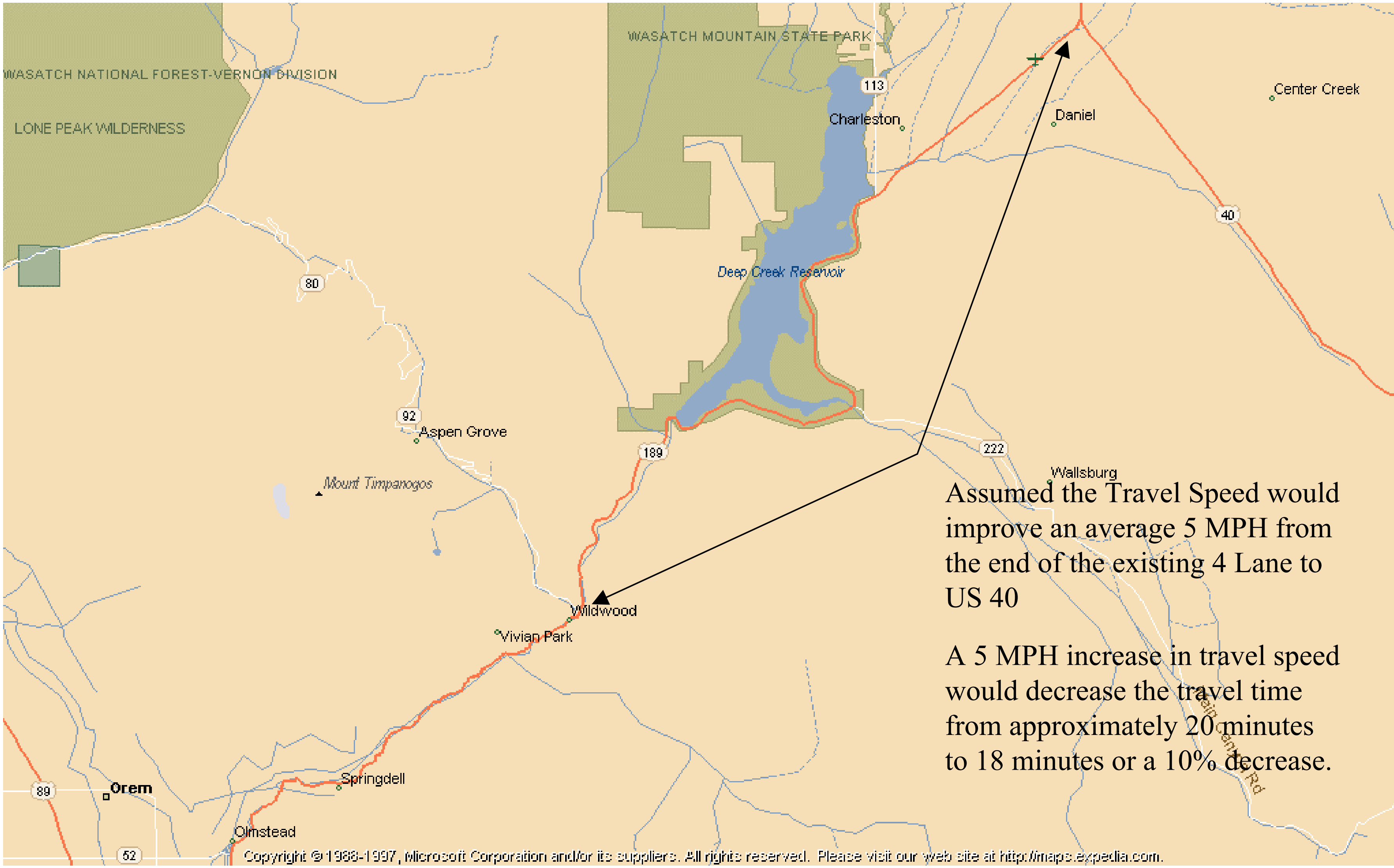
Work trips were gathered from the 1990 census and used to determine the amount of work trips thru Provo Canyon. Table 3 shows the work trips in between Utah and Wasatch Counties. In 1990 the AADT was 6,947 vehicle trips and of these trips 14% were work related trips. With the economic growth of both Utah and Wasatch Counties the traffic trend will reflect less work trips in between counties. Since the work trips are such a small percentage of the AADT, induced travel considered off peak travel times noting that the locational decision of the induced trips would take advantage of the off peak travel times.

TABLE 3
PROVO CANYON TRAFFIC ANALYSIS
Work Trips from Utah and Wasatch Counties

Work Trips From…	Work Trips To…					
	Utah County		Wasatch County		Other	
Utah County	88,543	89%	123	0.1%	10,835	10.9%
Wasatch County	379	9.4%	2,139	52.9%	1,527	37.8%

Therefore, based on the off-peak travel time improvement projected with improvements to US-189, as seen in Figure 11, induced travel will likely increase traffic volumes in the year 2020 by between approximately 1040 to 1340 vehicles per day, or 6.0 percent of the forecast daily traffic volume. The impact will also be felt in the design hour resulting in a high-end forecast of approximately 180 additional vehicles in the design hour. This high end forecast scenario was used to find a worse case induced hourly volume.

FIGURE 11
PROVO CANYON TRAFFIC ANALYSIS
Travel Time Estimate for Proposed Improvements



IV. DIVERTED TRAFFIC

This section of the report addresses the issue of the potential for traffic to divert from other routes to US 189 through Provo Canyon as a result of the proposed roadway improvements. US 189 serves as an alternate route to Interstate-80 through Parleys Canyon for those vehicles going south of Salt Lake City. The proposed improvements on US 189 would make the route through Heber City, Provo Canyon and Provo more appealing to some drivers and thus, a measurable number of drivers may divert.

A. Theory

There are several factors affecting the route drivers decide to take. The following is a list of some of these factors:

- Travel Time
- Distance
- Speed
- Grade
- Roadway Characteristics
- Driver Familiarity with Route

Travel time is usually the most important factor in a driver's decision. However, based on travel time estimates measured in the field, the US 40/US 189 route is actually four minutes faster than the I-80/I-15 route yet most drivers will stay on the interstate. In this case, familiarity, speed, and roadway characteristics are more significant factors than travel time and distance.

It is difficult to consider all factors affecting a drivers route selection and therefore, difficult to quantify the amount of traffic that will divert to a route based on new roadway improvements. The next section discusses one method developed to attempt to quantify diverted traffic.

One method used to estimate diverted traffic based on roadway improvements was published by the United States Department of Transportation in a document titled *A Probabilistic Multipath Traffic Assignment Model Which Obviates Enumeration*. The National Cooperative Highway Research Program (NCHRP) Synthesis 165 documents this method developed by Robert Dial, of the Volpe Center. Although this is typically a good method for estimating traffic diversion, the formulas break down when applied to the I-80/Parleys Canyon and US 189/Provo Canyon corridors.

The "Dial" method uses a natural logarithmic formula in which the volumes and travel times for two alternate routes are used to calculate a diversion parameter. The method assumes that the route traffic is being diverted *from* (in this case, I-80/I-15) has a lower travel time for the subject route than route traffic is being diverted *to* (US 40/US 189). Since the travel time along the US 40/US 189 route is actually shorter than the travel time along the I-80/I-15 route, the formula breaks down and results in a negative value.

B. Weigh Station Survey

In order to assess the potential for trucks to divert to the US 40/US 189 Corridor, truck drivers were interviewed at the Echo Port of Entry Weigh Station on I-80 Westbound near the Utah/Wyoming state line. A similar survey was conducted for the 1989 SEIS.

Figure 12 is a blank copy of the questionnaire used to record truck drivers responses to the survey questions. These questions were designed to obtain the most useful information from the drivers trip without spending an unreasonable amount of time to collect the information. The survey was conducted on Friday, May 18, 2000 from 10:00 AM to 6:00 PM. Unlike the survey done for the 1989 study where drivers where interviewed in their trucks as they passed over the scales, the weigh station officials pulled trucks over randomly and the drivers came inside the station to be interviewed. This resulted in a significantly lower sample size for year 2000 survey. The 1989 survey interviewed 776 drivers over a two-day period while the 2000 survey interviewed 89 drivers over the eight hour period, or about one in every 10 trucks.

One of the results of the survey is illustrated in Figure 13. This map shows the distribution of westbound trucks for the three canyon corridors. Seven of the 89 (8%) truck drivers interviewed already choose the Provo Canyon corridor. Figure 14 breaks down the distribution on I-80 for those trucks going south on I-15 and those continuing west on I-80. The chart shows a comparison to the 1989 survey. Although survey sample size was much smaller in the 2000 survey, the distribution is almost identical to the 1989 survey except for a 10% shift from I-80 to I-84 presumably due to the I-15 construction closures.

FIGURE 12
PROVO CANYON TRAFFIC ANALYSIS
Provo Canyon Truck Survey

Truck Type:
- ☐ 1. Single Trailer
- ☐ 2. Double Trailer
- ☐ 3. Triple Trailer
- ☐ 4. Gravel or Dump Truck
- ☐ 5. Other

Cargo:
- ☐ 1. Agriculture
- ☐ 2. Petroleum
- ☐ 3. Household Goods
- ☐ 4. Construction Equipment
- ☐ 5. Other

Where did your trip Start ?

City: ____________________ State: ____________________

Where was your last Stop ?

City: ____________________ State: ____________________

Where will your Stops be in Utah?

City/Cities: ______________________________

____

Where is your final destination?

City: ____________________ State: ____________________

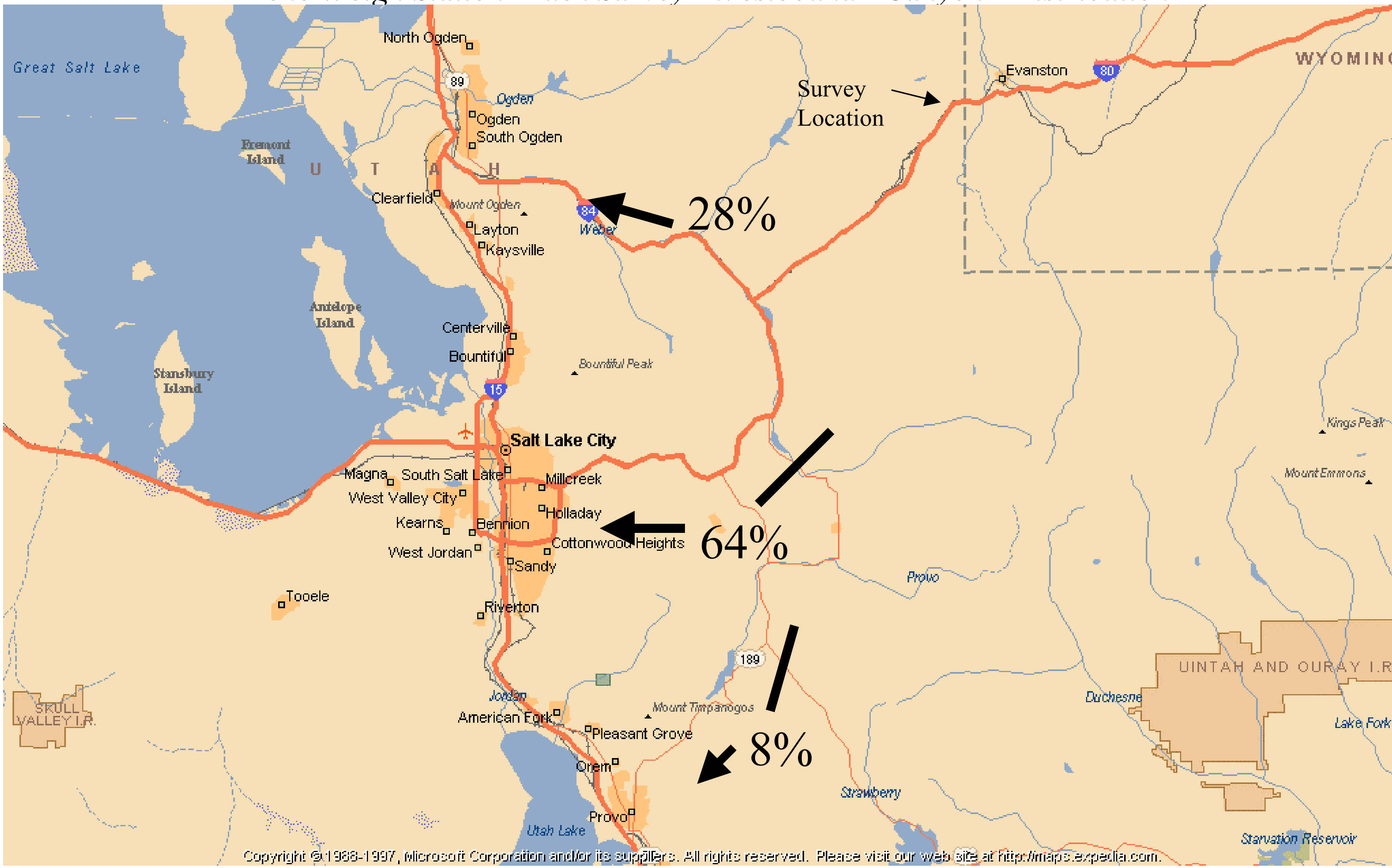
Which Route will you take today?
- ☐ 1. I-80 - Parleys Canyon
- ☐ 2. I-84 - Morgan Canyon
- ☐ 3. SR 189 - Provo Canyon

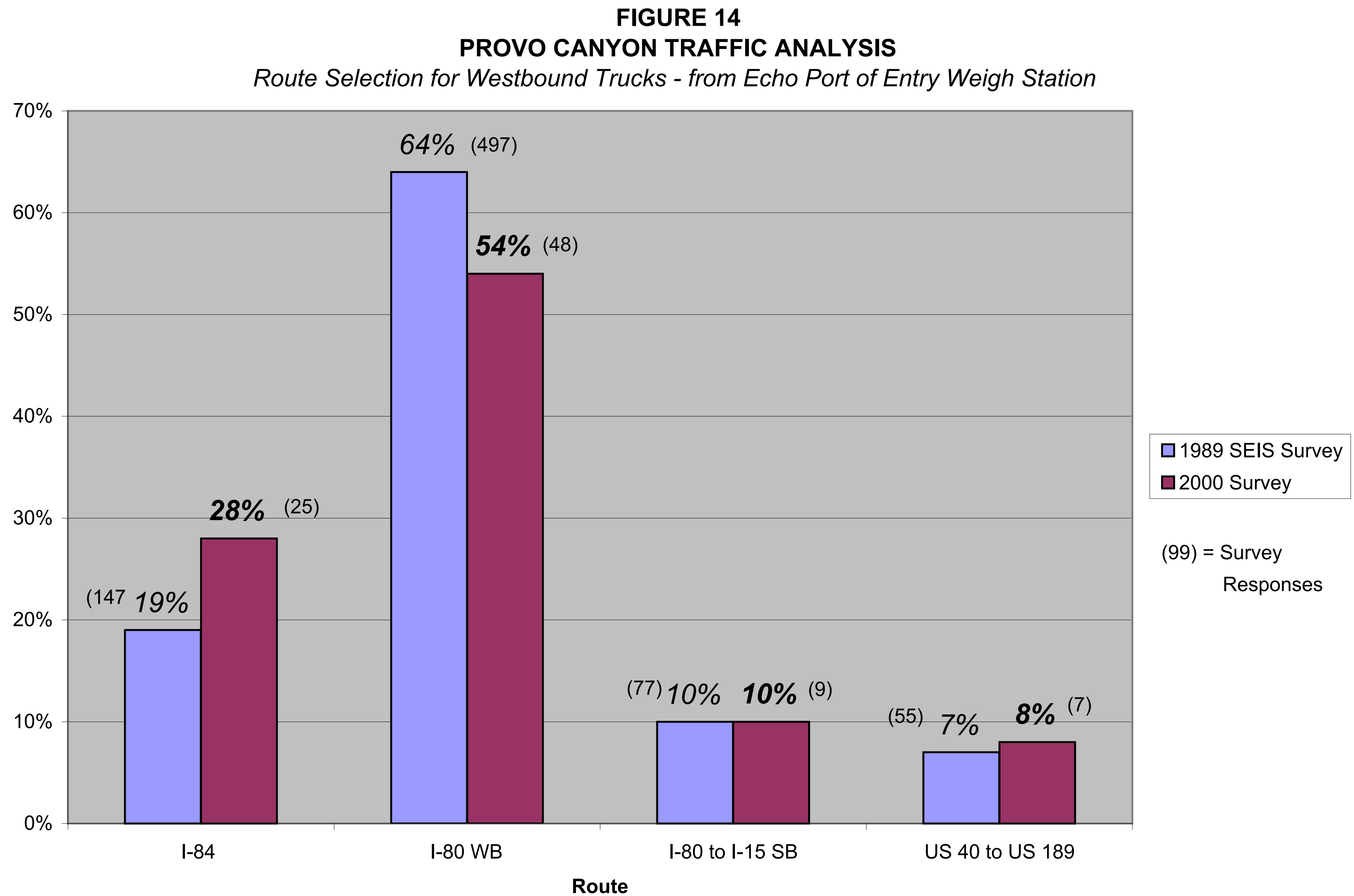
Which route would you take for the same exact trip under the following conditions?

1. Delays on I-15 through Salt Lake County because of Construction?
   - ☐ 1. I-80 - Parleys Canyon
   - ☐ 2. I-84 - Morgan Canyon
   - ☐ 3. SR 189 - Provo Canyon
2. Completion of 10 Lane I-15 through most of Salt Lake County?
   - ☐ 1. I-80 - Parleys Canyon
   - ☐ 2. I-84 - Morgan Canyon
   - ☐ 3. SR 189 - Provo Canyon
3. Delays on SR 189 through Provo Canyon because of Construction?
   - ☐ 1. I-80 - Parleys Canyon
   - ☐ 2. I-84 - Morgan Canyon
   - ☐ 3. SR 189 - Provo Canyon
4. Completion I-15 through Salt Lake and Completion of SR 189 as a 4 Lane Divided highway with a 50 MPH design speed through Provo Canyon (Heber City to Orem)?
   - ☐ 1. I-80 - Parleys Canyon
   - ☐ 2. I-84 - Morgan Canyon
   - ☐ 3. SR 189 - Provo Canyon

FIGURE 13
PROVO CANYON TRAFFIC ANALYSIS

Echo Weigh Station Truck Survey - Westbound "Canyon" Distribution





Fehr and Peers Associates Inc.

Table 4 gives the destination of truck drivers and draws a comparison to the 1989 survey. Again the results are nearly identical. It is interesting to note that 100 % (3 drivers) of the trucks ending their trip in the Provo area already use US 189.

TABLE 4
PROVO CANYON TRAFFIC ANALYSIS
Distribution of Truck Destinations [1]

Destination	1989 SEIS	2000 Fehr and Peers Study	Difference
Salt Lake City	32%	26%	-6%
Other Utah Cities	12%	13%	+1%
Northern California	25%	27%	+2%
Southern California	19%	15%	-4%
Southwestern States (NV, AZ)	2%	2%	0%
Northwest (ID, OR, WA)	10%	15%	+5%
Canada	0%	2%	+2%

1. Truck Survey at Echo Weigh Station

Table 5 shows the distribution of cargo type. The majority of the cargo being hauled is household goods. Many of the trucks were hauling cargo that did not fit into one of the four generic cargo types listed.

TABLE 5
PROVO CANYON TRAFFIC ANALYSIS
Distribution of Cargo Type[1]

Cargo Type	Percent
Agriculture	6%
Petroleum	3%
Household Goods	54%
Construction Equipment	9%
Other	28%

1. Truck Survey at Echo Weigh Station

C. Diverted Truck Traffic

The main purpose of the truck survey was to collect empirical data to estimate the number of truck drivers that would divert to an improved Provo Canyon. In addition to the route the truck drivers took that day, truck drivers were asked if they would use the US 40/US 189 route if US 189 were improved to a 4-lane divided highway. A total of 13 truck drivers were headed to Southern California. Currently, nine of these drivers use the I-80/I-15 route or 69%. The other four drivers destined for Southern California already use the Provo Canyon route. Six of the nine truck drivers said they would use the Provo Canyon route for a total of 10 out of 13 total trucks or 77%. These numbers are drastically different from the 1989 survey which resulted in only 19% of all trucks destined for Southern California selecting the Provo Canyon route. Figure 15 shows this comparison between the 1989 survey and the 2000 survey.

Although the response from the truck drivers suggests an overwhelming percentage of trucks would divert their trips to an improved US 189, the survey results were not considered to be representative for the following reasons:

- A four minute time savings is not significant for a 10 hour travel day
- Most interstate truck drivers were not familiar with the US 40/US 189 route and therefore could not make an educated guess as to whether they would use the route
- Truck drivers typically find Interstate routes more desirable
- The total cross section of the survey sample size was only 13 drivers

For these reasons the drivers response to the diversion questioned was skewed. In factoring the number of trucks that said they would divert in the 2000 survey to a daily total, approximately 200 interstate trucks a day would divert if US 189 were improved today. However, the actual amount of diverted interstate trucks is estimated to be half of what the survey indicates or 100 daily trucks, due to the factors listed above. Since the average daily traffic is expected to nearly double by the year 2020, the number of diverted trucks each day in the year 2020 will be about 200 to 300. This equates to approximately 20 additional trucks in the peak hour (200 x 10% peak hour factor). This is consistent with the 1989 SEIS which estimates the number of daily diverted trucks will be 160 in the year 2010.

D. Diverted Passenger Car Traffic

Although the number of induced passenger car trips on an improved US 189 will be measurable as discussed in the previous section, diverted passenger car traffic will be very minimal. Long distance travelers will remain on the familiar interstate highways. The uncertainty of the surface streets and traffic signals will deter state to state drivers from the US 40/US189 route. Only a few local trips that may have used I-15/I-80 would divert to a new four-laned Provo Canyon. Drivers from Riverton/Draper area or the American Fork/Lehi area may choose Provo Canyon over Parleys to get to Park City, or the recreational areas in the Uintas. (See Figure 16) However, Fehr and Peers estimates that these diverted passenger cars will only be about 10 to 20 trips a day or less than 0.01% of the daily traffic.

FIGURE 15
PROVO CANYON TRAFFIC ANALYSIS
Truck Survey at Echo Weigh Station - Route Selection for Trucks Going Southwest of Utah

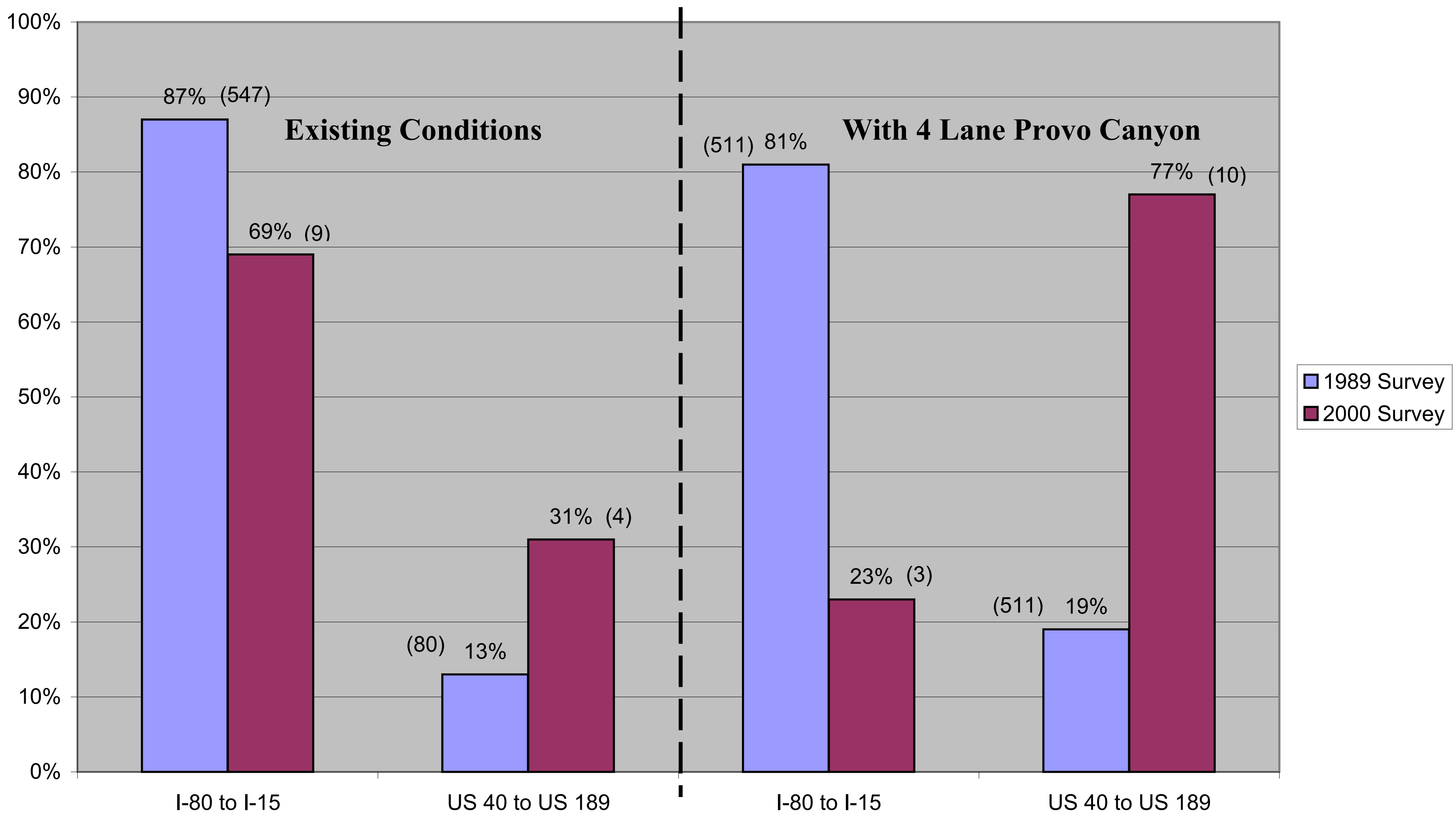
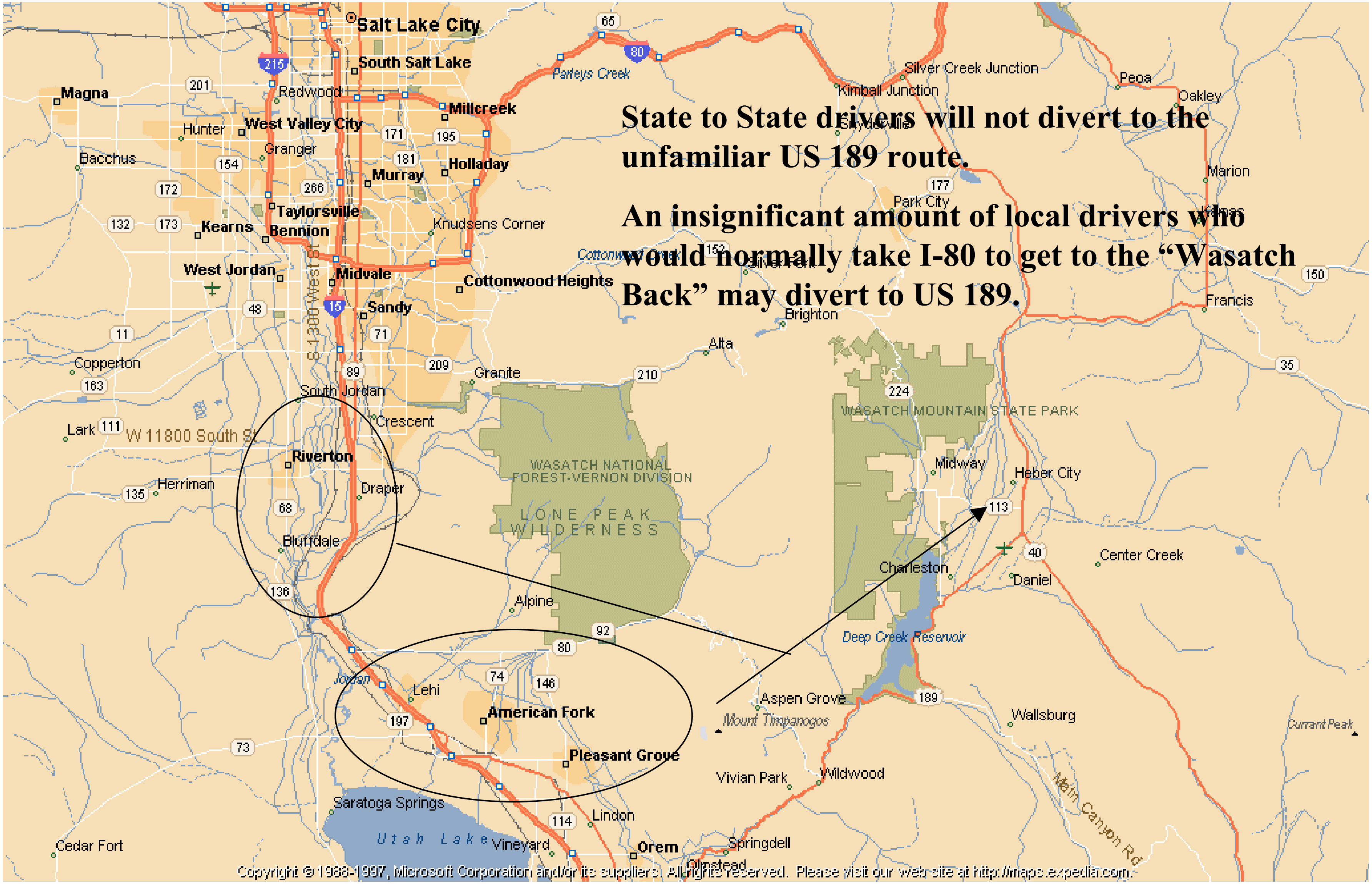


FIGURE 16
PROVO CANYON TRAFFIC ANALYSIS
Passenger Car Diversion



V. SAFETY

This section of the report addresses the issue of safety along the US 189 corridor through Provo Canyon. To analyze this issue, crash data was acquired from the Utah Department of Transportation – Traffic and Safety. Crash data was obtained for the entire decade of the 1990's. Due to the construction in the Canyon over the last decade, no significant trends can be identified.

The total number of crashes for the entire corridor has fluctuated from 111 crashes in 1993 to 178 crashes in 1998. The average number of crashes in the 1990's is 147 per year. The number of crashes has remained fairly constant in comparison to the numbers reported in the 1989 SEIS. The average number of crashes from 1985 to 1987 for the entire corridor was 144 per year. These values are illustrated in Figure 17.

The heavy construction years of 1992, 1997 and 1998 had more crashes than non-construction years and it appears that crashes have risen consistently with traffic volumes from 1993 to 1996. The decline in 1999 appears to be a result of the end of construction of the four lanes from the mouth of the canyon to SR 92 as was the case in 1993 after the construction in 1992.

The number of crashes in the four-lane section has decreased from 78 in 1998 to 60 in 1999 on the existing four-lane segment. This equates to a 23% reduction in crashes, however, no trend can be assumed since the construction has only been completed one year and the average number of crashes on this lower section is 63 crashes per year during non-construction years. The average number of crashes reported in the 1989 SEIS from 1985 to 1987 is 73 per year on this section.

Similarly, no accident trends exist for the existing two-lane segment of the corridor. The total number of crashes on the upper segment of the corridor has fluctuated between 55 and 98 crashes per year over the last ten years with an average of 80 crashes per year. The average number of crashes reported in the 1989 SEIS for the 1985 to 1987 years was 71 crashes per year.

Consistent with the total number of crashes, the average crashes rates have not changed significantly since the 1989 SEIS which reports that the accident rates in Provo Canyon are higher than a typical two-lane facility in the Utah. The overall average accident rate for the entire corridor from 1990 to 1999 is about 2.4 crashes per million vehicle miles. The average crash rate for a two-lane highway in the Utah is 1.8. This indicates that the corridor has a higher crash rate than a typical two-lane highway.

More important than the total number of crashes is the number of fatalities that have occurred in the canyon. Figure 18 shows the total number of fatalities for the entire corridor over the last ten years. The number of fatalities has fluctuated from 0 to 4 and no trends are apparent. The average number of fatalities from 1985 to 1987 was 4. In isolating the existing four-lane segment, fatalities are still occurring in a random fashion. One trend did surface when analyzing the accident data closely.

Three fatalities occurred within a four-month period near the Bridal Veil Falls intersection in 1999. This intersection is included in the widened four-lane segment of the corridor. These fatalities could be possibly attributed to drivers watching the falls as the pass and not paying attention to the road. A closer look at the cause of these fatalities indicates that all three crashes involved single vehicles. One involved a cyclist and the other two the vehicle swerved off the road and hit a fixed object. No other fatalities have occurred at the intersection in the 8 years before the widening. This intersection should be more closely analyzed in the future SEIS.

With the exception of the Bridal Veil Falls intersection, no overall conclusions can be drawn from the accident data. However, future data may continue to indicate a steady decline in crashes in the existing four-lane section of the corridor.

FIGURE 17
PROVO CANYON TRAFFIC ANALYSIS
Total Crashes in Provo Canyon - US 189 from SR 52 (800 North) to US 40

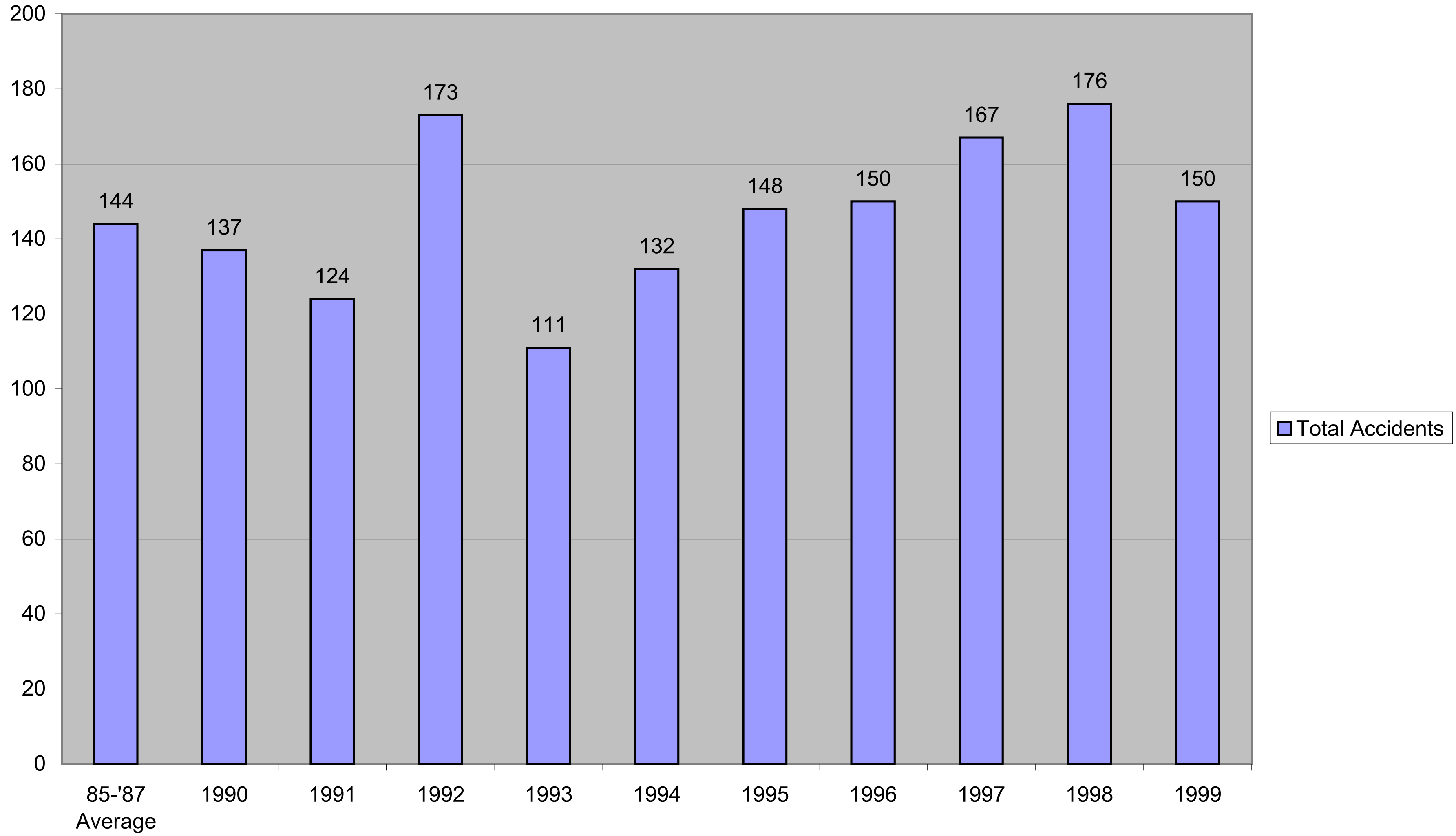
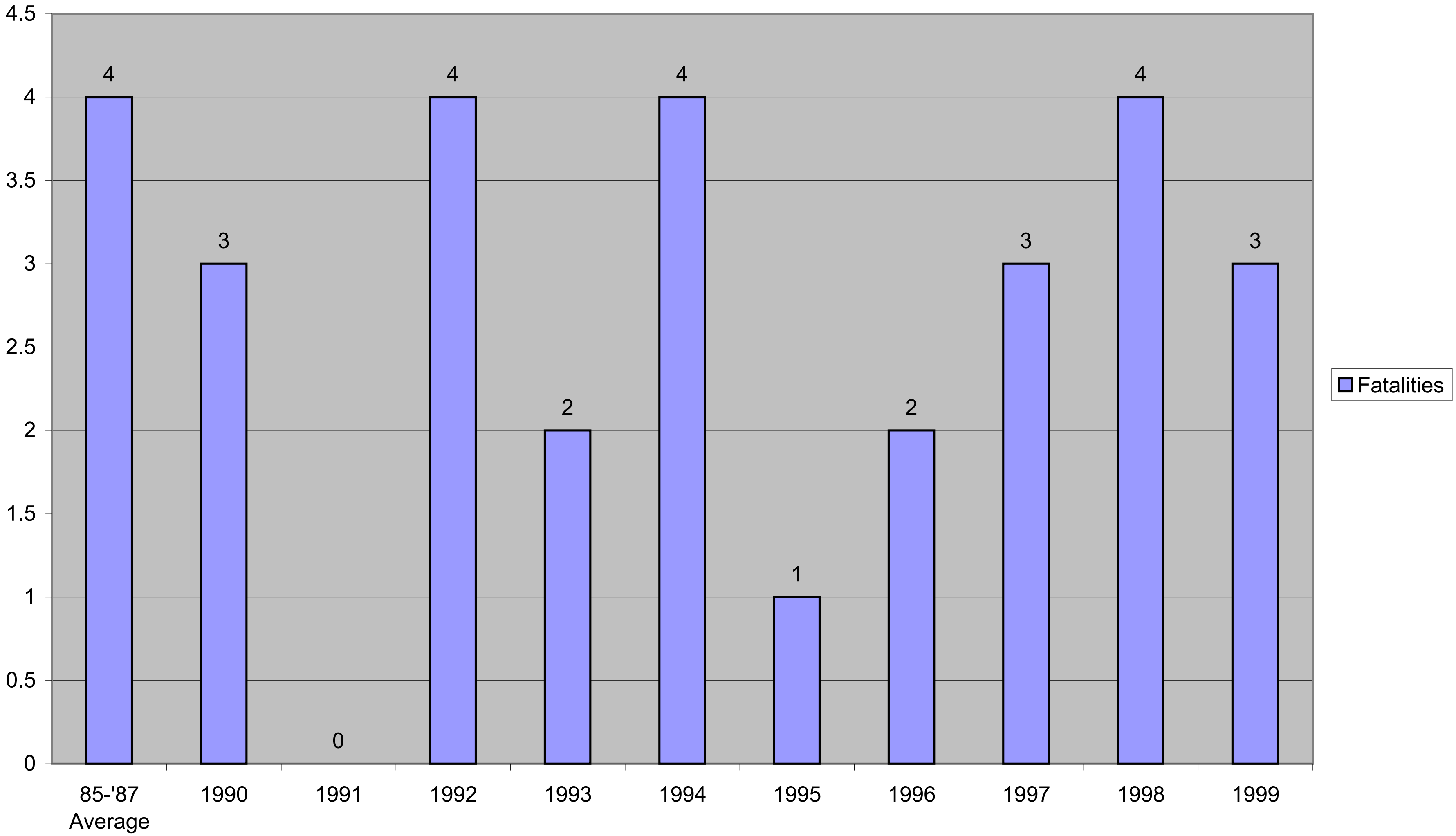


FIGURE 18
PROVO CANYON TRAFFIC ANALYSIS
Fatalities in Provo Canyon - US 189 from SR 52 (800 North) to US 40



VI. CAPACITY ANALYSIS

This section of the report addresses the issue of existing and proposed capacity for the corridor. There are several factors that effect the capacity of a highway beyond the number of lanes and other geometric characteristics of a roadway. The following is a list of factors influencing the capacity of a two-lane highway:

- Directional Split
- Truck Percentage
- Passing Zones

Previous studies have shown significant variability in the directional split and truck percentages along the corridor. The 1989 SEIS reported that the directional split in the 50th highest hour was 65%/35% for most of the corridor. The 1994 study conducted by MK Centennial averaged the 30th to 60th highest hours and estimated a 45%/55% split.

Figure 19 is a chart illustrating the variations in the truck percentages from different sources. The 40th highest hour from the 1994 study reported 15.5% RV's and 1.8% heavy trucks. Recent counts collected by UDOT in June 2000 indicate 9.2% heavy trucks and 2.7% Single Unit trucks or RV's in the peak hour. UDOT reports an Average Annual truck percentage of 5% heavy trucks and 2% single unit trucks in their *1998 Truck Percentages on Utah Highways*. Since the directional split and the truck percentage vary significantly, the capacity of the US 189 corridor is estimated as a range instead of a single value.

1997 Highway Capacity Software (HCS) was used to determine the capacity of the subject corridor. A "bottle neck" or critical segment was identified to isolate the worst section of the corridor. Figure 20 illustrates the limits of this critical segment from the end of the existing four-lane segment to the end of the "mountainous terrain" at the Dear Creek Reservoir. This segment contains a variation in grades and has approximately 70% of its length marked as a no passing zone. This value was reported in the 1994 study and confirmed in the field during this analysis. These two factors were used in *HCS* as well as the previously discussed high and low truck percentages and directional splits to calculate a capacity range for the critical section. The capacity (Level of Service E/F) range for the critical section of the existing two-lane is approximately 1,200 to 1,500 vehicles per hour.

Similarly, the capacity of the proposed four lane widening of Provo Canyon also is estimated as a range using the high and low truck percentages. The capacity range for the proposed four-lane improvement is approximately 4,900 to 5,800 vehicles per hour.

These values are illustrated in Figure 21 Design Hour Traffic. These capacity thresholds are significant in demonstrating the level of congestion the subject corridor will experience in the next several years. This will be further discussed in the next section.

Also shown on Figure 21 graph is the LOS C/D threshold. To calculate that value, the most recent average daily truck percentages from UDOT's 2000 traffic counts were used. This truck percentage (last column in Figure 20) is the average of five days in the month of June including a weekend. The LOS C/D threshold is approximately 3,400 vehicles per hour. Printouts from the *HCS* software are presented in the Appendix.

FIGURE 19
PROVO CANYON TRAFFIC ANALYSIS
Historical Truck Percentages US 189 - Provo Canyon

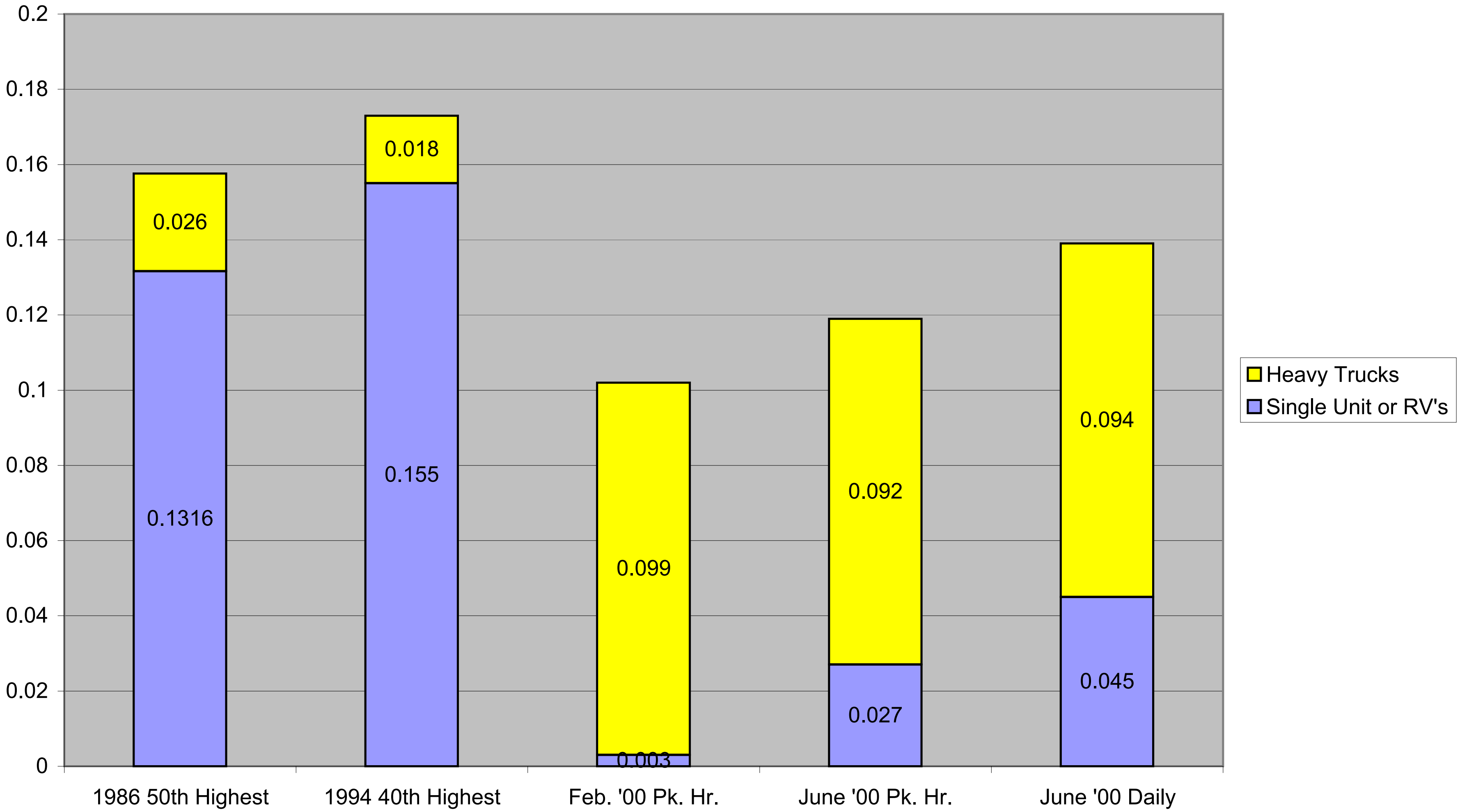


FIGURE 20
PROVO CANYON TRAFFIC ANALYSIS
Capacity Analysis Assumptions

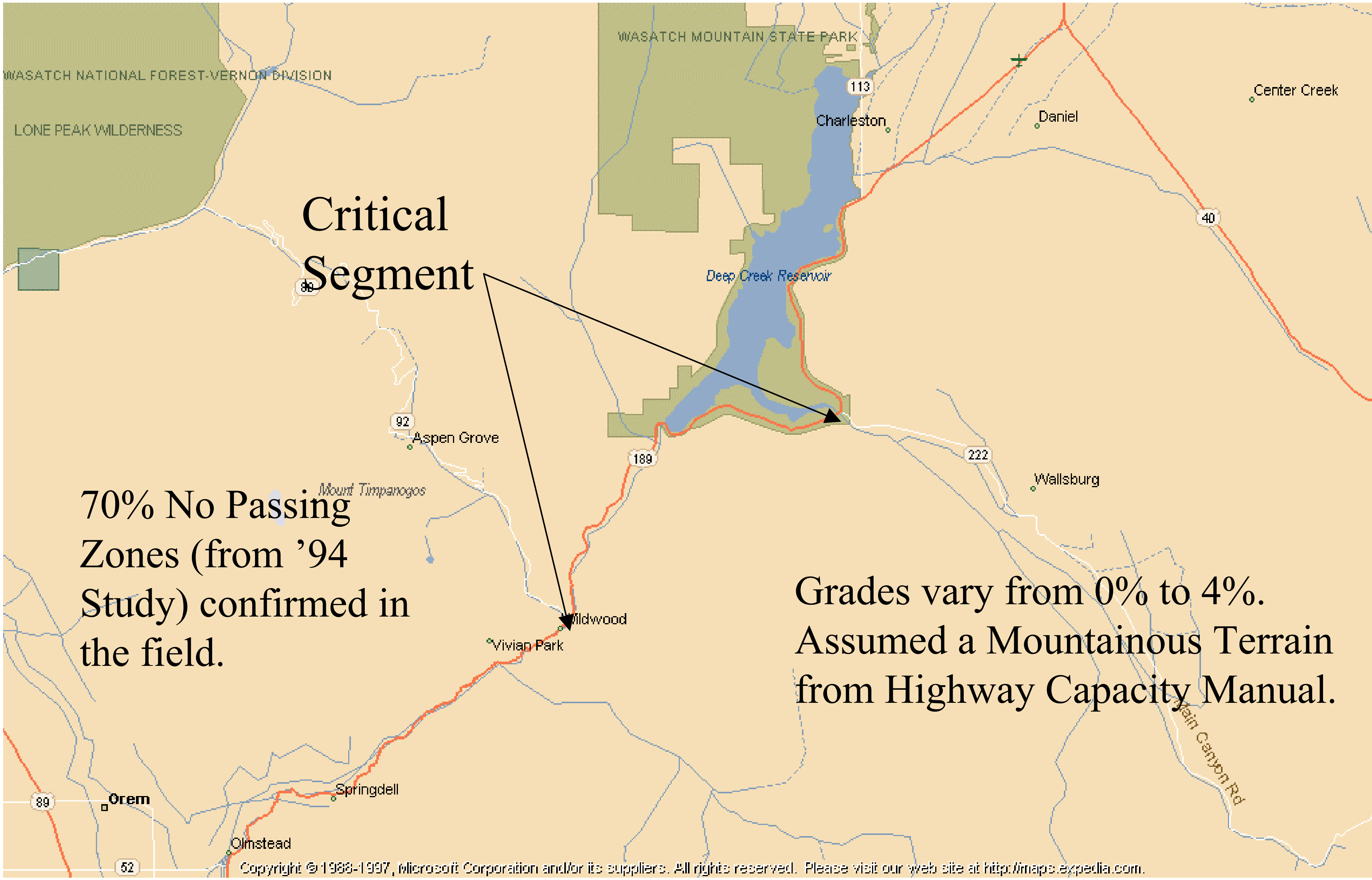
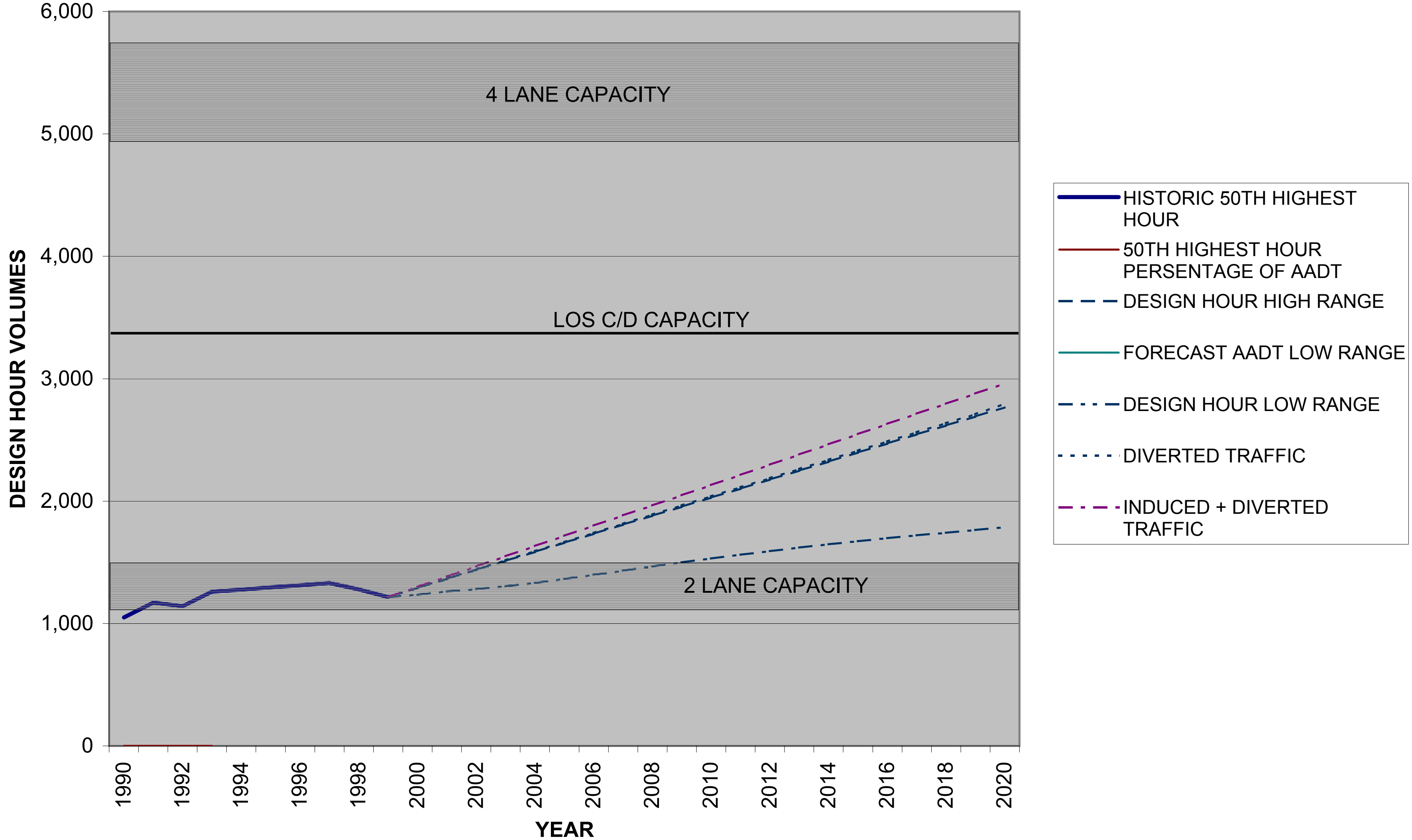


FIGURE 21
PROVO CANYON TRAFFIC ANALYSIS
Design Hour Traffic



*Design Hour = 50th Highest Hour.

VII. FINDINGS AND RECOMMENDATIONS

As discussed, traffic in Provo Canyon has been analyzed for many years, with environmental documents completed in 1978, 1989, and 1995. An important component of this effort, in addition to re-evaluating historic data and developing independent conclusions, is to consider more recent data and to identify changes in traffic conditions or traffic related conclusions. To this end, the following bullets highlight changes reflected in this recent analysis that do not appear to be included in previous analysis:

- Induced traffic has been estimated and results in a small fraction of overall traffic.

- Diverted traffic has been estimated by a recent survey and may be slightly higher than the 1989 SEIS, but still remains a very small number.

- Design hourly volumes continue to be based on the 50^{th} highest hour, but this hour has been decreasing as a percent of average daily traffic.

The improvements proposed in the earlier analyses appear to be necessary. The overall conclusion related to the inability of the existing road to accommodate the expected growth of traffic remains valid. The following bullets summarize many of the conclusions stated and substantiated in other sections of this report.

- Traffic growth will continue at a strong rate, mirroring the rate of population and employment in Wasatch and Utah Counties.

- The existing road cross section is inadequate to accommodate the projected levels of traffic and is already experiencing level of service failures during peak periods during the year.

- Safety improvements will likely result from the roadway widening as well as various related improvements to access points and non-motorized users.

- Concerns of induced traffic and/or diverted traffic appear to be real issues but only affect total traffic volumes by a very small fraction of total traffic which do not alter other traffic related conclusions.

- Roadway improvements are based on a design hour which is significantly lower than the highest hour of traffic. There are variations in truck percentage, directional split and other issues which make a determination of the exact roadway capacity in that hour impossible. However, given a range of capacities and accounting for slower growth in the design hourly traffic than in the average daily traffic, the roadway improvements are needed to accommodate a level of service C in the design year 2020.

Appendix

1985 HCM:TWO-LANE HIGHWAYS
****

FACILITY LOCATION.... US 189 - SR 92 to Dam
ANALYST.............. kaz
TIME OF ANALYSIS..... Year 2020
DATE OF ANALYSIS..... 06-28-2000
OTHER INFORMATION.... Lowest Capacity - 35/65 Split - 13 % RV 's, 2% Trucks

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS......................... 2
PERCENTAGE OF BUSES.......................... 0
PERCENTAGE OF RECREATIONAL VEHICLES.......... 13
DESIGN SPEED (MPH)........................... 50
PEAK HOUR FACTOR............................. .95
DIRECTIONAL DISTRIBUTION (UP/DOWN)........... 35 / 65
LANE WIDTH (FT).............................. 12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.).... 8
PERCENT NO PASSING ZONES..................... 70

B) CORRECTION FACTORS

MOUNTAINOUS TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	7	5.7	5	1	.92	.61
B	10	6	5.2	1	.92	.58
C	10	6	5.2	1	.92	.58
D	12	6.5	5.2	1	.92	.57
E	12	6.5	5.2	1	.92	.57

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 1789
ACTUAL FLOW RATE: 1883

LOS	SERVICE FLOW RATE	V/C
A	62	.04
B	193	.13
C	341	.23
D	588	.4
E	1190	.82

LOS FOR GIVEN CONDITIONS: F

HCS: Multilane Highways Release 3.1b

hone:
-mail:

Fax:

OPERATIONAL ANALYSIS

lighway:	Provo Canyon US 189
Analyst:	
From/To:	SR-92 to Dam
Analysis Year:	2020 LOSC/D 9%truck,3%RV
Length:	
Date:	7/31/00

FREE-FLOW SPEED

Direction	1		2	
Free-Flow Speed:	Ideal		Ideal	
FFS or FFSi	50.0	mph	50.0	mph
Median Type	Divided		Divided	
Median Type Adjustment, FM	0.0	mph	0.0	mph
Lane Width	12.0	ft	12.0	ft
Lane Width Adjustment, FLW	0.0	mph	0.0	mph
Lateral Clearance:				
Right Edge	2.0	ft	2.0	ft
Left Edge	6.0	ft	6.0	ft
Total Lateral Clearance	8.0	ft	8.0	ft
Lateral Clearance Adjustment, FLC	0.9	mph	0.9	mph
Access Points per Mile	0		0	
Access Points Adjustment, FA	0.0	mph	0.0	mph
Adjusted Free-Flow Speed	49.1	mph	49.1	mph

VOLUME

Direction	1		2	
Volume, V	1696	vph	1696	vph
Peak-Hour Factor, PHF	0.95		0.95	
Peak 15-Minute Volume, v15	446		446	
Number of Lanes	2		2	
Terrain Type	Mountainous		Mountainous	
Grade	0.00	%	0.00	%
Segment Length	0.00	mi	0.00	mi
Trucks and Buses	9	%	9	%
Trucks and Buses PCE, ET	6.0		6.0	
Recreational Vehicles	3	%	3	%
Recreational Vehicles PCE, ER	4.0		4.0	
Heavy Vehicle Adjustment, fHV	0.65		0.65	
Driver Population Adjustment, fP	1.00		1.00	
Service Flow Rate, vp	1374	pcphpl	1374	pcphpl

RESULTS

Direction	1		2	
Service Flow Rate, vp	1374	pcphpl	1374	pcphpl
Adjusted Free-Flow Speed, FFS	49.1	mph	49.1	mph
Avg. Passenger-Car Travel Speed, S	49.1	mph	49.1	mph
Level of Service, LOS	C		C	
Density, D	28.0-	pc/mi/ln	28.0-	pc/mi/ln

HCS: Multilane Highways Release 3.1b

Phone:
E-mail:

Fax:

OPERATIONAL ANALYSIS

Highway: Provo Canyon US 189
Analyst:
From/To: SR-92 to Dam
Analysis Year: 2020, LOS E/F
Length:
Date: 7/5/00

FREE-FLOW SPEED

Direction	1		2	
Free-Flow Speed:	Ideal		Ideal	
FFS or FFSi	50.0	mph	50.0	mph
Median Type	Divided		Divided	
Median Type Adjustment, FM	0.0	mph	0.0	mph
Lane Width	12.0	ft	12.0	ft
Lane Width Adjustment, FLW	0.0	mph	0.0	mph
Lateral Clearance:				
Right Edge	2.0	ft	2.0	ft
Left Edge	6.0	ft	6.0	ft
Total Lateral Clearance	8.0	ft	8.0	ft
Lateral Clearance Adjustment, FLC	0.9	mph	0.9	mph
Access Points per Mile	0		0	
Access Points Adjustment, FA	0.0	mph	0.0	mph
Adjusted Free-Flow Speed	49.1	mph	49.1	mph

VOLUME

Direction	1		2	
Volume, V	2500	vph	2431	vph
Peak-Hour Factor, PHF	0.95		0.95	
Peak 15-Minute Volume, v15	658		640	
Number of Lanes	2		2	
Terrain Type	Mountainous		Mountainous	
Grade	0.00	%	0.00	%
Segment Length	0.00	mi	0.00	mi
Trucks and Buses	2	%	2	%
Trucks and Buses PCE, ET	6.0		6.0	
Recreational Vehicles	13	%	13	%
Recreational Vehicles PCE, ER	4.0		4.0	
Heavy Vehicle Adjustment, fHV	0.67		0.67	
Driver Population Adjustment, fP	1.00		1.00	
Service Flow Rate, vp	1960	pcphpl	1906	pcphpl

RESULTS

Direction	1		2	
Service Flow Rate, vp	1960	pcphpl	1906	pcphpl
Adjusted Free-Flow Speed, FFS	49.1	mph	49.1	mph
Avg. Passenger-Car Travel Speed, S	45.6	mph	45.9	mph
Level of Service, LOS	E		E	
Density, D	43.0-	pc/mi/ln	41.5	pc/mi/ln

HCS: Multilane Highways Release 3.1b

one:
mail:

Fax:

OPERATIONAL ANALYSIS

_ghway:	Provo Canyon US 189
ınalyst:	
~om/To:	SR-92 to Dam
alysis Year:	2020, LOS E/F 4%truck, 2% RV
ıngth:	
ıate:	7/5/00

FREE-FLOW SPEED

Direction	1		2	
~ee-Flow Speed:	Ideal		Ideal	
FFS or FFSI	50.0	mph	50.0	mph
ıdian Type	Divided		Undivided	
ledian Type Adjustment, FM	0.0	mph	1.6	mph
ıne Width	12.0	ft	12.0	ft
ıne Width Adjustment, FLW	0.0	mph	0.0	mph
ıteral Clearance:				
Right Edge	2.0	ft	2.0	ft
Left Edge	6.0	ft	6.0	ft
Total Lateral Clearance	8.0	ft	8.0	ft
ıteral Clearance Adjustment, FLC	0.9	mph	0.9	mph
\ccess Points per Mile	0		0	
~ccess Points Adjustment, FA	0.0	mph	0.0	mph
ljusted Free-Flow Speed	49.1	mph	47.5	mph

VOLUME

Direction	1		2	
Volume, V	2956	vph	2874	vph
Peak-Hour Factor, PHF	0.95		0.95	
ıak 15-Minute Volume, v15	778		757	
umber of Lanes	2		2	
Terrain Type	Mountainous		Mountainous	
Grade	0.00	%	0.00	%
Segment Length	0.00	mi	0.00	mi
:ucks and Buses	4	%	4	%
Trucks and Buses PCE, ET	6.0		6.0	
Recreational Vehicles	2	%	2	%
ecreational Vehicles PCE, ER	4.0		4.0	
ıavy Vehicle Adjustment, fHV	0.79		0.79	
Driver Population Adjustment, fP	1.00		1.00	
Service Flow Rate, vp	1960	pcphpl	1906	pcphpl

RESULTS

Direction	1		2	
ervice Flow Rate, vp	1960	pcphpl	1906	pcphpl
Adjusted Free-Flow Speed, FFS	49.1	mph	47.5	mph
Avg. Passenger-Car Travel Speed, S	45.6	mph	44.3	mph
evel of Service, LOS	E		E	
ensity, D	43.0-	pc/mi/ln	43.0-	pc/mi/ln

1985 HCM:TWO-LANE HIGHWAYS
****

FACILITY LOCATION.... US 189 - SR 92 to Dam
ANALYST.............. kaz
TIME OF ANALYSIS..... Year 2020
DATE OF ANALYSIS..... 06-28-2000
OTHER INFORMATION.... Highest Capacity - 45/55 split - 4% Hea vy Trucks, 2% RV's

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................ 4
PERCENTAGE OF BUSES......................... 0
PERCENTAGE OF RECREATIONAL VEHICLES......... 2
DESIGN SPEED (MPH).......................... 50
PEAK HOUR FACTOR............................ .95
DIRECTIONAL DISTRIBUTION (UP/DOWN).......... 45 / 55
LANE WIDTH (FT)............................. 12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)... 8
PERCENT NO PASSING ZONES.................... 70

B) CORRECTION FACTORS

MOUNTAINOUS TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	7	5.7	5	1	.97	.76
B	10	6	5.2	1	.97	.69
C	10	6	5.2	1	.97	.69
D	12	6.5	5.2	1	.97	.66
E	12	6.5	5.2	1	.97	.66

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 1789
ACTUAL FLOW RATE: 1883

LOS	SERVICE FLOW RATE	V/C
A	82	.04
B	245	.13
C	433	.23
D	713	.4
E	1461	.82

LOS FOR GIVEN CONDITIONS: F